# DOCUMENT RESUME

| | |
|---|---|
| ED 158 963 | SE 024 076 |
| AUTHOR | Zuchorski, Edward, Jr., Ed. |
| TITLE | Pesticide Applicator Training Manual, Category 3 - Ornamentals and Turf for New York State. A Training Program for the Certification of Commercial Pesticide Applicators. |
| INSTITUTION | Cornell Univ., Ithaca, N.Y. Cooperative Extension Service. |
| PUB DATE | Jun 76 |
| NOTE | 189p.; For related documents, see SE 024 072-077; Photographs may not reproduce well |
| EDRS PRICE | MF-$0.83 HC-$10.03 Plus Postage. |
| DESCRIPTORS | Certification; Entomology; *Environment; *Equipment Utilization; *Instructional Materials; Job Skills; *Ornamental Horticulture; *Pesticides; *Post Secondary Education; Safety; Turf Management |
| IDENTIFIERS | Pests |

ABSTRACT

This manual provides information needed to meet specific standards for certification as a pesticide applicator. Each of the eight chapters deals with a different aspect of pesticide use. Chapter one discusses the problems of use as it relates to safety of humans and the environment. Chapter two is concerned with the identification and diagnosis of insects and disease while the third chapter discusses equipment types and their utilization. The remaining chapters deal with insects, diseases and weeds of turf and ornamentals. (CS)

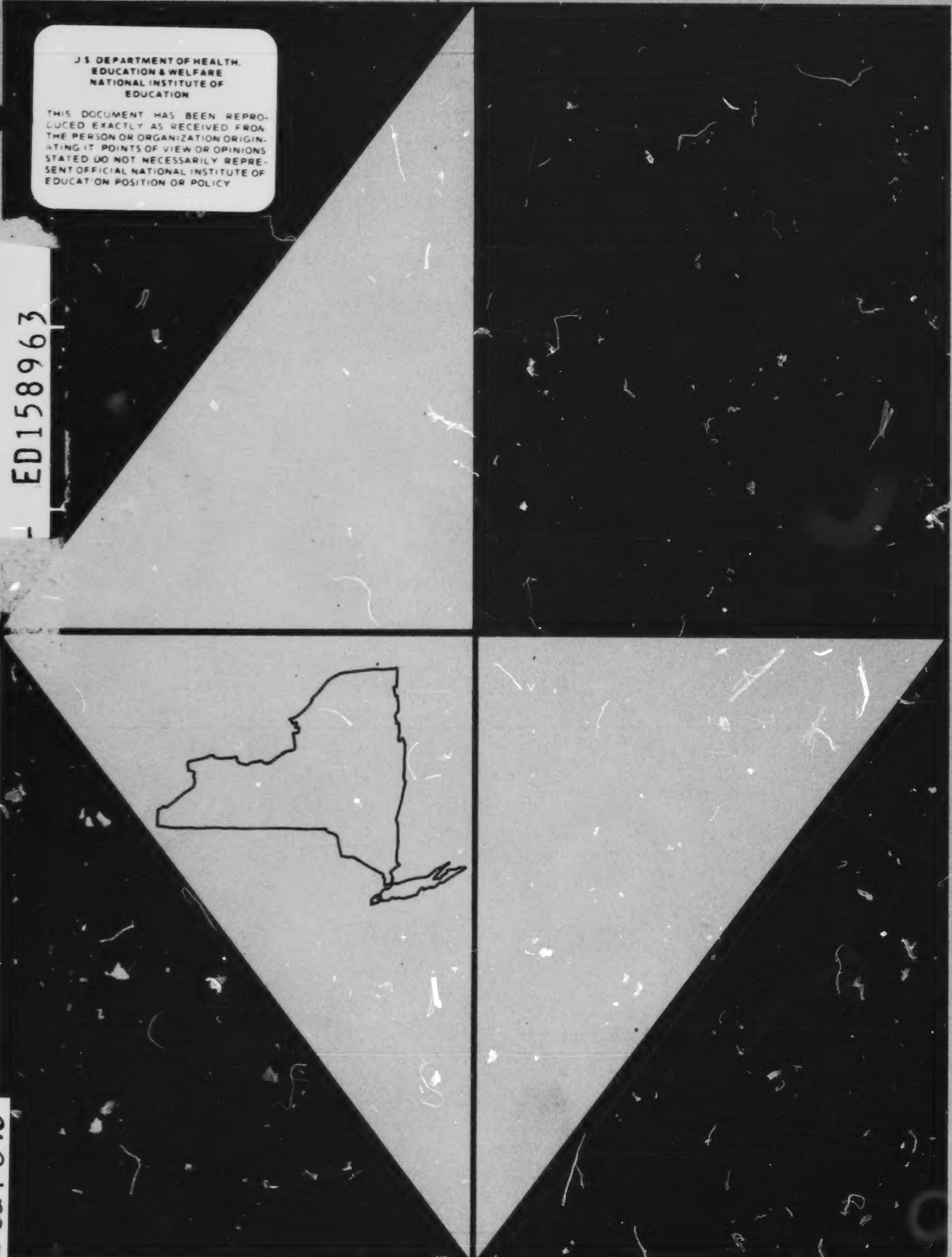
***********************************************************************
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
***********************************************************************

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

ED158963

SE 024 076



# INSTRUCTIONS FOR USING THIS TRAINING MANUAL

This training manual is intended to provide you with the information you will need to meet the standards of the Environmental Protection Agency for Commercial Pesticide Applicator Certification, and to prepare you to take an examination given by the New York State Department of Environmental Conservation based on this manual. It is not intended that this training will provide you with all the information you need for effective ornamental and turf pest control -- you are requested to obtain a copy of Cornell Recommendations for Pest Control for Commercial Production and Maintenance of Trees and Shrubs ($1.35) and Cornell Recommendations for Turfgrass (free) from your local Cooperative Extension agent.

The manual is designed to be used as a self-study training program, one that you can study at your own pace and convenience.

- Review the Table of Contents
- You will be responsible for the general information found in Chapters 1, 2, and 3.
- Chapter 3 deals with Equipment; the first section is general, the second section is more specific to the equipment you may already be using. You will be responsible only for that equipment that pertains to your specific category training.
- You will be responsible only for the specific information found in Chapters 4 - 9 that pertains to your category training. For example, if you are a turf manager you should be familiar with Turf - Insects, Diseases and Weeds. Another example, Landscaper: you should be familiar with pests of both ornamentals and turf.
- The examination will be an open book, consisting of 50 questions, mostly multiple choice. Bring manual plus both copies of Cornell Recommendations to the exam. You will need all three to take the exam.
- Complete the 12 practice questions that are enclosed (Answers given on bottom of sheet).
- Remember your exam date!

## Reminders

Your core manual is your basic information manual for all pesticide applicators. The commercial category manual (Ornamental-Turf) takes off from where the core manual left off. Refer back to your core manual as necessary.

You should place your commercial category manual in the same binder as your core manual.

# NOTICE OF EXAMINATION

Commercial Pesticide Applicator Certification

Your examination is scheduled for:

If for some reason you cannot take the examination on the above date, you will have to request another date -- Remove lower portion of this card and drop card in mail.

### Reminder

Bring your manual plus both copies of Cornell Recommendations to the Exam. You will need all three to take the exam.

I cannot attend my scheduled examination

New York State College of Agriculture and Life Sciences, New York State College of Human Ecology, and New York State Veterinary College at Cornell University, Cooperative Extension Associations, County Governing Bodies, and United States Department of Agriculture, cooperating.

COOPERATIVE EXTENSION
U. S. DEPARTMENT OF AGRICULTURE
ROBERTS HALL, CORNELL UNIVERSITY
ITHACA, NEW YORK 14853

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF
AGRICULTURE
AGR 101

U.S.MAIL

Dr. James E. Dewey
Department of Entomology
Comstock Hall
Cornell University
Ithaca, NY 14853

# PESTICIDE APPLICATOR TRAINING MANUAL

## CATEGORY 3

## ORNAMENTALS AND TURF

## FOR

## NEW YORK STATE

A Training Program for the Certification
of Commercial Pesticide Applicators

Cooperative Extension
Chemicals-Pesticides Program
New York State College of Agriculture and Life Sciences
at
Cornell University, Ithaca, New York
June 1976

6

# TABLE OF CONTENTS

Page

INTRODUCTION 1

Chapter

1 PROBLEMS WITH PESTICIDE USE . . . . . . . . . . . . . . . . . . . . 4

-- Hazards. . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
-- Respirators and Gas Masks. . . . . . . . . . . . . . . . . . . 5
-- Reentry. . . . . . . . . . . . . . . . . . . . . . . . . . . . 7
-- Days to Harvest. . . . . . . . . . . . . . . . . . . . . . . . 8
-- Phytotoxicity. . . . . . . . . . . . . . . . . . . . . . . . . 10
-- Bees . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10
-- Drift. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 10
-- Contamination. . . . . . . . . . . . . . . . . . . . . . . . . 13
-- Specific Use Problems. . . . . . . . . . . . . . . . . . . . . 17
-- Special Use Pesticides . . . . . . . . . . . . . . . . . . . . 19
-- Growth Regulators. . . . . . . . . . . . . . . . . . . . . . . 19
-- Desiccants and Defoliants. . . . . . . . . . . . . . . . . . . 20
-- Soil Pesticides. . . . . . . . . . . . . . . . . . . . . . . . 21
-- Safety . . . . . . . . . . . . . . . . . . . . . . . . . . . . 23
-- Mixing Pesticides. . . . . . . . . . . . . . . . . . . . . . . 24
-- Mixtures of Pesticides and Fertilizers . . . . . . . . . . . . 27
-- Serial Applications of Pesticides. . . . . . . . . . . . . . . 27
-- Adjuvants. . . . . . . . . . . . . . . . . . . . . . . . . . . 28

2 PESTS . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30

-- Identification and Diagnosis . . . . . . . . . . . . . . . . . 30
-- Causes of Injury to Plants . . . . . . . . . . . . . . . . . . 30
-- Insects. . . . . . . . . . . . . . . . . . . . . . . . . . . . 31
-- Ways Insects Injure Plants . . . . . . . . . . . . . . . . . . 32
-- Diseases . . . . . . . . . . . . . . . . . . . . . . . . . . . 33
-- Ways Diseases Injure Plants. . . . . . . . . . . . . . . . . . 34
-- Nematodes. . . . . . . . . . . . . . . . . . . . . . . . . . . 35
-- Ways Nematodes Injure Plants . . . . . . . . . . . . . . . . . 36
-- Weeds. . . . . . . . . . . . . . . . . . . . . . . . . . . . . 37
-- Ways Weeds Injure Plants . . . . . . . . . . . . . . . . . . . 37
-- Collecting Specimens for Identification. . . . . . . . . . . . 37
-- Economic Considerations. . . . . . . . . . . . . . . . . . . . 37

Chapter Page

2 Pests (Cont'd.)
-- Life Cycle . . . . . . . . . . . . . . . . . . . . . . 39
-- Other Methods of Control . . . . . . . . . . . . . . . . 40

3 PESTICIDE APPLICATION EQUIPMENT . . . . . . . . . . . . . 41
-- Components of Pesticide Application Equipment . . . . . 42
-- Tanks . . . . . . . . . . . . . . . . . . . . . . . . 42
-- Agitators . . . . . . . . . . . . . . . . . . . . . . 43
-- Strainers . . . . . . . . . . . . . . . . . . . . . . 44
-- Pumps . . . . . . . . . . . . . . . . . . . . . . . . 44
-- Pressure Regulators . . . . . . . . . . . . . . . . . 47
-- Pressure Gauge . . . . . . . . . . . . . . . . . . . . 48
-- Selector and Shut-Off Valves . . . . . . . . . . . . . 49
-- Hoses . . . . . . . . . . . . . . . . . . . . . . . . 49
-- Pesticide Equipment . . . . . . . . . . . . . . . . . 50
-- Multipurpose Sprayers . . . . . . . . . . . . . . . . 52
-- Boom Sprayers - Low Pressure & High Pressure . . . . . . 53
-- Nozzle Bodies . . . . . . . . . . . . . . . . . . . . 54
-- Nozzle Tips . . . . . . . . . . . . . . . . . . . . . 54
-- Fan or Flat Pattern Nozzles . . . . . . . . . . . . . 55
-- Broadcast or Boomless Nozzle . . . . . . . . . . . . . 56
-- Flooding Fan . . . . . . . . . . . . . . . . . . . . . 57
-- Full Cone or Hollow Cone . . . . . . . . . . . . . . . 57
-- Nozzle Screens . . . . . . . . . . . . . . . . . . . . 58
-- Calibration of Boom Sprayers . . . . . . . . . . . . . 59
-- High Pressure Sprayers (Hydraulic) . . . . . . . . . . 59
-- Airblast Sprayers . . . . . . . . . . . . . . . . . . 60
-- Mist Blowers . . . . . . . . . . . . . . . . . . . . . 65
-- Granular Application . . . . . . . . . . . . . . . . . 67
-- Broadcast Applicators . . . . . . . . . . . . . . . . 67
-- Band or Row Applicators . . . . . . . . . . . . . . . 68
-- Soil Fumigation Application . . . . . . . . . . . . . 70
-- Tarpaulin Fumigation . . . . . . . . . . . . . . . . . 73
-- Aerial Application . . . . . . . . . . . . . . . . . . 75
-- Injection and Implantation . . . . . . . . . . . . . . 76
-- Operating Precautions for Pesticides Equipment . . . . . 80
-- Cleaning the Sprayer . . . . . . . . . . . . . . . . . 81

Chapter Page

3 Pesticide Application Equipment (Cont'd.)

-- Storing the Sprayer. . . . . . . . . . . . . . . . . . . . 81

-- Some Common Sprayer Troubles . . . . . . . . . . . . . . . 83

4 ORNAMENTALS - INSECTS . . . . . . . . . . . . . . . . . . . 84

-- Aphids . . . . . . . . . . . . . . . . . . . . . . . . . . 84

-- Birch Leafminer. . . . . . . . . . . . . . . . . . . . . . 85

-- Black Vine (Taxus) Weevil. . . . . . . . . . . . . . . . . 87

-- Bronze Birch Borer . . . . . . . . . . . . . . . . . . . . 88

-- Cankerworms. . . . . . . . . . . . . . . . . . . . . . . . 89

-- Eastern Spruce Gall Aphid. . . . . . . . . . . . . . . . . 91

-- Elm Bark Beetles . . . . . . . . . . . . . . . . . . . . . 92

-- Gypsy Moth . . . . . . . . . . . . . . . . . . . . . . . . 93

-- Japanese Beetles . . . . . . . . . . . . . . . . . . . . . 95

-- Pine Needle Scale. . . . . . . . . . . . . . . . . . . . . 96

-- Pine Sawflies. . . . . . . . . . . . . . . . . . . . . . . 98

-- Spider Mites . . . . . . . . . . . . . . . . . . . . . . . 100

-- White Pine Weevil. . . . . . . . . . . . . . . . . . . . . 102

5 ORNAMENTALS - DISEASES. . . . . . . . . . . . . . . . . . . 108

-- Apple Scab . . . . . . . . . . . . . . . . . . . . . . . . 108

-- Cedar-Apple Rust . . . . . . . . . . . . . . . . . . . . . 109

-- Cytospora Canker of Spruce . . . . . . . . . . . . . . . . 111

-- Diplodia Tip Blight. . . . . . . . . . . . . . . . . . . . 112

-- Dutch Elm Disease. . . . . . . . . . . . . . . . . . . . . 113

-- Hawthorn Leafblight. . . . . . . . . . . . . . . . . . . . 115

-- Juniper Twig Blight. . . . . . . . . . . . . . . . . . . . 116

-- Lophodermium-Needlecast of Pine. . . . . . . . . . . . . . 117

-- Rhabdocline-Needlecast of Douglas Fir. . . . . . . . . . . 118

-- Pine Gall Rust (Western Gall Rust) . . . . . . . . . . . . 119

-- Phytophthora . . . . . . . . . . . . . . . . . . . . . . . 120

-- Powdery Mildew . . . . . . . . . . . . . . . . . . . . . . 121

-- Sycamore Anthracnose . . . . . . . . . . . . . . . . . . . 122

Chapter Page

6 ORNAMENTALS - WEEDS . . . . . . . . . . . . . . . . . . . . . . . . 126

-- Bindweed (Field) . . . . . . . . . . . . . . . . . . . . . . . 127
-- Nutsedge . . . . . . . . . . . . . . . . . . . . . . . . . 127
-- Poison Ivy . . . . . . . . . . . . . . . . . . . . . . . . 128
-- Purslane . . . . . . . . . . . . . . . . . . . . . . . . . 129
-- Quackgrass . . . . . . . . . . . . . . . . . . . . . . . . 130
-- Yellow Foxtail . . . . . . . . . . . . . . . . . . . . . . . 130

7 TURF - INSECTS . . . . . . . . . . . . . . . . . . . . . . . . . 132

-- Chinch Bug . . . . . . . . . . . . . . . . . . . . . . . . 132
-- Grubs (Japanese Beetle, European Chafer) . . . . . . . . . 134
-- Hyperodes Weevil . . . . . . . . . . . . . . . . . . . . . . 138
-- Sod Webworm . . . . . . . . . . . . . . . . . . . . . . . . 139

8 TURF - DISEASES . . . . . . . . . . . . . . . . . . . . . . . . . 142

-- Dollar Spot . . . . . . . . . . . . . . . . . . . . . . . . 143
-- Fusarium Blight . . . . . . . . . . . . . . . . . . . . . . 144
-- Leaf Spot . . . . . . . . . . . . . . . . . . . . . . . . . 146
-- Brown Patch . . . . . . . . . . . . . . . . . . . . . . . . 147

9 TURF - WEEDS . . . . . . . . . . . . . . . . . . . . . . . . . . 151

-- Annual Bluegrass . . . . . . . . . . . . . . . . . . . . . . 156
-- Chickweed . . . . . . . . . . . . . . . . . . . . . . . . . 157
-- Crabgrass . . . . . . . . . . . . . . . . . . . . . . . . . 157
-- Dandelion . . . . . . . . . . . . . . . . . . . . . . . . . 158
-- Plantain . . . . . . . . . . . . . . . . . . . . . . . . . . 159
-- Veronica, Creeping Speedwell . . . . . . . . . . . . . . . . 159

ACKNOWLEDGEMENTS . . . . . . . . . . . . . . . . . . . . . . . . . 161

# INTRODUCTION

You have completed the core training of pesticide certification and now are about to start additional training for your commercial certification. This manual will cover information in the following commercial categories:

a) Agricultural (plant)
b) Forestry
c) Ornamentals and Turf

You will be responsible for the general information that appears in Chapters I, II, and III, along with the specific information that pertains to your category training, but not for all the information presented. For example, if you are a turf manager, you would not be expected to know the pests associated with tree fruit, or vegetables, or how to calibrate orchard airblast equipment.

The purpose of this manual is to:

-- provide federal minimum category standards for certification
-- provide identity to some common problems in the use of pesticides
-- provide identity to some common pests
-- provide methods of calibration, maintenance and operations of equipment used in the application of pesticides in agriculture

This manual focuses on principles which apply to your operations and which will enable you to improve your competency to use pesticides.

## Standards for Certification

The Environmental Protection Agency has set minimum standards for certification of pesticide applicators. Among these standards is a section relating to your operations as a commercial applicator.

The specific standards from the Federal Register for this category of commercial applicators are as follows:

> "Applicators must demonstrate practical knowledge of crops on which they may be using restricted use pesticides (non-restricted as well in New York State). The importance of such competency is amplified by the extensive areas involved, the quantities of

> pesticides needed, and the ultimate use of many commodities of food and feed. Practical knowledge is required concerning soil and water problems, preharvest intervals, reentry intervals, phytotoxicity, and potential for environmental contamination, non-target injury and community problems resulting from the use of restricted use pesticides in agricultural areas".

You will need specific information for your local situation. Cooperative Extension and your industry organization are sources for such information.

## Responsiblity for Certification

It is the Environmental Protection Agency's responsibility to see that minimum standards are met. A lead agency is designated in each state that is responsible to EPA for certification training and enforcement. The Department of Environmental Conservation is the lead agency for New York State. Within the agency the Bureau of Pesticides has all regulatory responsibilities dealing with pesticides, including preparing and giving the examinations for certification and enforcing the requirements.

Cooperative Extension is responsible for training pesticide applicators in preparation for certification. The core level of training for both private and commercial applicators is offered in individual counties through the local Cooperative Extension field staff. Category training is offered by teams of specialists (mainly from Cornell), usually on a regional basis. All examinations are administered by a representative of DEC.

## Crops and Pests

Commercial applicators must demonstrate practical knowledge of crops grown and the specific pests of these crops on which they may be using restricted use pesticides.

Your full and adequate knowledge of crops and pests for which you provide service is basic to performance of your work. You must:

- accurately identify the pests
- apply the most effective and efficient control measures
- determine the necessity of chemical control
- select the correct registered pesticides

With this knowledge, your ability to provide safe and effective service to your customers or employer will be greater.

Concern for Others

Practical knowledge is required to recognize:

-- soil and water problems - leaching, residues, erosion, etc.
-- the potential for contamination of water by your pesticide application
-- preharvest intervals and reentry intervals.

    Preharvest intervals and reentry intervals are established to protect the consumer from harmful residues and the safety of your workers. It is your responsibility to ensure that each customer is completely informed about these intervals.

-- phytotoxicity and potential for environmental contamination.

    Bad habits and sloppy practices can result in environmental contamination which can be avoided or reduced by careful supervision to maintain strict adherence to approved methods and label directions.

-- nontarget injury

    Areas adjacent to the target crop may receive pesticide drift. This can result in either harmful residues on food or feed crops or, in the case of some herbicides, may result in plant injury.

-- community problems (such as "in-line" housing, streams, ponds, or lakes, school grounds, etc.) resulting from the use of pesticides in agricultural areas.

Careless habits resulting in misuse, littering the landscape, and contamination of the environment are not only prohibited by law but also contribute to bad public relations.

Your concern for the environment including people who live, play, or work near your operations, is vital to your future.

## I. PROBLEMS WITH PESTICIDE USE

Your core manual deals mostly with the acute hazards of pesticides to man and other warm blooded animals that are associated with handling of highly toxic pesticides. As a commercial applicator you are daily exposed to many pesticides ranging from low to high toxicity. You must consider their total effect on yourself, and such possible side effects as phytotoxicity, bee toxicity, drift damage, reentry, residues, tolerances, etc. Your health and repeat business depends on your knowledge and care in application.

### Hazards to the Applicator, Worker and Consumer

#### Dermal Toxicity to the Applicator

You must not swallow, touch, or inhale pesticides. Your greatest hazard from pesticides is from skin contact which results in absorption through the skin. According to a survey in a leading agricultural state, absorption through the skin was responsible for over 80% of the cases of poisoning from agricultural and industrial use of agricultural chemicals. This can result from a splash, spill, or drift when you and/or your help are mixing or applying the chemical, or from contact with a pesticide "deposit" or "residue" after it has been applied.

The hazard of skin absorption is increased by cuts, abrasions, scratches, scuffs, or other damage to the skin. However, absorption can occur rapidly even through healthy skin. Absorption is high and rapid through the scrotum, arm pit, ear canal, forehead and scalp. It is lower and slower in the palm of the hand, or ball of the foot. However, even in these lower absorption areas, penetration can be great and vary from material to material. Carbaryl (Sevin) for example, is thought of as a relatively safe material, but is absorbed through the skin of the forearm about seven times more rapidly than malathion or parathion. Whether highly toxic or relatively safe, any pesticide spilled or splashed on the skin should be washed off immediately. Studies show that pesticides can be absorbed within a few minutes. Waiting until a job is done before washing may be too late! Wash by rubbing the hands together or with a piece of cloth using detergent or soap. Do not scrub with a brush since the outer protective layer of the skin may be scratched enough to allow more rapid absorption of any pesticide which is not removed. Hands should be protected with gloves when working on spray machinery.

### Eyes

Eyes are particularly sensitive to harm by pesticides and should be protected with goggles or a face shield. If pesticide is splashed into the eye, immediately wash it with a gentle stream of clean running water while holding the eyelid open. A few seconds delay greatly increases the extent of injury. Large amounts of water should be used and continued for 15 minutes or more. Do not use chemicals or drugs in wash water. They may increase the injury. Convenient plastic eye wash bottles and holders are now available. These useful bottles can be purchased from chemical laboratory suppliers and are called "eye wash stations."

### Lungs

Most applicators do not feel that inhalation of pesticides is a serious hazard. It is next in importance to skin contact as a cause of agricultural accidents. Because the lungs have such a large and highly absorptive surface area, even small amounts of pesticide are hazardous because they are almost completely absorbed. Vapors and extremely fine particles, 10 microns or smaller, are a particular hazard. Field tests in fruit orchards with airblast sprayers using eight times the normal dilute concentration have shown that the respiratory hazard is about three times greater than when operating with conventional dilute sprayers. Respirators should be worn as indicated on the pesticide label and whenever else that you think such protection is desirable. Occasional use of most moderately toxic pesticides does not usually require use of a respirator. Daily use of these pesticides, however, greatly increases your exposure and may necessitate use of a respirator. It is also wise to wear a respirator when using moderately toxic pesticides such as malathion during the same day or days that you are using highly toxic pesticides of the same family.

#### Respirators and Gas Masks for Pesticides

All respirators intended for use with pesticides must be approved jointly by the Mining Enforcement and Safety Administration (MESA) and the National Institute of Occupational Safety and Health (NIOSH). Approval numbers beginning with the letters TC are assigned to all respirators approved by the new agency. This number must be on the box containing the facepiece. Cartridges and filters approved for pesticides are necessary and must have the TC number affixed to them plus the part number of the replacement part. Chemical cartridge respirators approved for pesticides will have the code number 23C following the letters TC and gas masks will have the number 14G following TC. Respirators having numbers other than TC numbers (i.e., BM numbers) are no longer approved unless they can be upgraded to meet requirements through the use of appropriate cartridges and filters.

As of April 1, 1976, it is our understanding that the following respirators are approved for pesticide use under the new standards:

Standard Chemical Cartridge Respirators

-- MSA number 459520 respirator with 459519 cartridge. Approval number TC-23C-45. Mine Safety Appliances Co.

-- Willson AGRI-TOX-2 respirator. 1200 series respirator with R21 Chemical Cartridges, R15 filters and R683 filter retainers. Approval Number TC-23C-54. Willson Products Division, ESB, Inc.

-- Welsh 7549 respirator with 7500-21 cartridges and 7500-23 filters. Approval number TC-23C-74. Welsh, A Textron Co.

-- MSA 448848 respirator with 448847 cartridges. Approval number TC-23C-79. Mine Safety Appliances Co.

-- AO number R5058 or R6058 respirator with R58 cartridge. Approval number TC-23C-106. Safety Products Division, American Optical Corp.

-- Pulmosan number C-241 respirator with TC-23C-81 organic vapor cartridge and C-241-7 filter. Approval number TC-23C-110. Pulmosan Safety Equipment Corp.

Powered Air Purifying Respirators

-- 3MW262 and W263 powered air purifying respirators with W2114 cartridge and W2031 filter. Approval number TC-23C-78. 3M Co.

Gas Masks

-- MSA Clearview or Ultraview Chin Style Gas Mask Systems with Pesticide Approved Canister (Numbers 448983, 448984, 448985, and 448986). Canister alone is 448972. Approval number TC-14G-86. Mine Safety Appliances Co.

Reentry Into Treated Fields - (Don't confuse with number of days from last spray to harvest).

These standards were established in 1974, apply particularly to agricultural uses and were established to protect workers. Although you as the commercial applicator may feel that you are not directly involved, there are some rules you must follow. These are:

1. No unprotected person may be in the field you are treating with any pesticide!
2. No pesticide application is to be permitted that will expose any person to pesticides, either directly, or through drift, excepting those involved in the application, who should be wearing protective clothing as required.
3. The label restrictions and directions must be followed.

Those pesticides presently (October 1975) restricted and requiring workers to wear protective clothing within the 24- or 48-hour reentry period after treatment are:

| 24 hours | 48 hours | |
|---|---|---|
| Guthion | ethyl parathion | carbophenothion |
| phosalone | methyl parathion | Meta-Systox-R |
| EPN | demeton | Bidrin |
| ethion | Azodrin | endrin |

It is your responsibility to keep abreast of changes in these pesticide restrictions.

Although not absolutely necessary any time that you apply one of the above materials, it is recommended that you notify your client to avoid misunderstanding, poor public relations and possible litigation. Tell him the name of the material, time of application and the required reentry period during which protective clothing must be worn so that he may inform his employees accordingly. If workers must enter fields prior to expiration of the required interval, growers are obligated to notify workers of the date of treatment and furnish them with protective clothing.

Fields treated with pesticides other than those listed above may be reentered without protective clothing after the spray has dried or the dust has settled. New labels will indicate the necessary reentry information, old labels will not (refer to list above).

State regulatory agencies may impose and enforce standards for workers that are more restrictive than those specified. Check your state regulations.

### Days to Harvest Interval

Don't confuse days-to-harvest intervals with reentry intervals. Days-to-harvest is the time that must pass between pesticide application and crop harvest to protect the consumer by allowing the pesticide residue to fall to or below a specific tolerance level. The same pesticide will have different intervals for different crops, based on dosages necessary to control pests, different surfaces treated, whether edible parts are treated, stripping or washing outer leaves, etc. Check the harvest interval before an application is made.

## Hazards to the Crop

Probably the greatest hazard to the crop is an adverse reaction to the chemical applied. "Phytotoxicity" or chemical injury results in stunting, burning, deforming, or death of the crop.

### Phytotoxicity or Chemical Injury

Pesticide injury to plants may be the result of direct application to the plant; spray, dust, or vapor drift onto the plant; runoff from a treated field or persistent soil residues which can damage a sensitive crop planted in an area previously treated. Injury to the plant may appear as dead, burned, or scorched spots on or at the tips of leaves; russeting of fruit; misshapen fruit, leaves, or plants; off-color; stunting; delayed development; poor germination; or complete death of the plant. Unfortunately, these signs of chemical spray injury often do not appear until several days after application. When they do appear, they are not always clearly understood and they are often confused with other problems such as: signs or symptoms of a disease; insect injury; uneven application of fertilizer; nutrient deficiency or excess; poor drainage or poor soil; frost injury; hail, drying winds; hot weather; shading; poor lighting; or air pollution. Generally, however, there are clues which help you solve the problem. Some are: location of injured plants; location of injured areas on the plant or fruit; nature of the injury itself; lack of signs of other causes of the injury such as ooze or fungus growing from the injured spot; weather records; cropping history; location in relation to highways, industrial plants, cities; etc. Sometimes it may be necessary to call upon experienced people to help determine the correct answer. Generally, the injured areas are sharply defined between injured and healthy tissue. Color of the injured area is usually uniform. Spots may be evenly distributed or confined to a spot where a drop of spray accumulated on the low area of the leaf or fruit.

The likelihood of plant injury resulting from the use of a pesticide varies with the chemical, the formulation used, the concentration, the method of application, the growing conditions and the stage or condition of the plant. Desiccants, defoliants and herbicides are effective because of their ability to kill foliage and destroy plants. They are, therefore, particularly hazardous through drift to sensitive plants. Organophosphates, carbamates, and oils are more likely to cause injury when drying conditions are poor. Chlorinated hydrocarbons, on the other hand, are more apt to be injurious in hot, dry weather. Emulsifiable concentrates, because of the solvents in them, are more likely to cause injury than wettable powders since they allow the chemical to come into direct contact with the plant tissue by dissolving the waxy protective layer on the leaves. Mixtures of pesticides, especially soluble or emulsifiable formulations, are more likely to cause injury in sensitive situations than materials applied individually. Similarly, applications with high pressures may cause injury when lower pressures would not. Injury may appear at the end of rows or near the edges of treated fields because of slower travel rates, turning and stops. Phytotoxicity may result under some of these conditions even when recommendations are followed. Severe injury, however, is unlikely and is a sign of other problems.

Growing conditions can also influence plant sensitivity to chemical injury. Weak plants such as those in shallow soils, wet spots, etc., are more susceptible to injury than are healthy plants. Young, tender, fast growing plants with large areas of new growth tend also to be more susceptible to injury. Differences in the sensitivity of varieties is not uncommon.

## Hazards to Non-target Areas or Organisms

These hazards are the result of a pesticide hitting the wrong target within the crop, drifting away from the crop, or being mishandled.

### Hazard to Bees (See inside of back cover)

Honey bees and wild bees are necessary for pollination of many crops. Many pesticides are highly toxic to honey bees, wild bees and other beneficial insects. You can reduce bee poisoning if you follow these suggestions:

-- Do not apply pesticides that are toxic to bees to crops that are in bloom, including cover and adjoining crops.

-- Select pesticides that will be least harmful to bees.

-- Try to choose the least harmful formulations. Dusts are more hazardous than sprays. Emulsifiable concentrates seem to have less residual toxicity than wettable powders. Granular formulations have the lowest hazard to bees.

-- Try to time pesticide applications so that the hazard to bees will be as low as possible. Evening applications are generally less hazardous than early morning. Both are safer than mid-day applications. For example, short residual pesticides might be applied at night between sunset and sunrise to minimize injury to foraging bees in the field needing treatment. Because corn and milo stop shedding pollen about noon, and bees collect the pollen, short residual pesticides should be applied in mid-afternoon or evening to protect the bees.

-- Do not treat near hives and try to avoid pesticide drift over or onto hives. Coarse sprays will help reduce drift. If a hazardous pesticide must be applied near hives, contact the beekeeper ahead of time and ask him to remove his bees.

-- When a cover crop is in bloom, as in an adjoining field, the grower may be able to greatly reduce the hazard by mowing it before treating.

### Drift

Pesticides are not pollutants as long as they stay on target. Drift of pesticides away from the target is probably the most important and costly problem facing most commercial applicators. Drift is important because of possible injury to non-target plants and animals, and illegal residues that may make neighboring food crops unsalable. Poor public relations with those living around the target area may cause the loss of use of effective pesticides because of their side effects, and may result in loss of certification because of misuse.

Drift is costly because of: possible lawsuits resulting from off-target injury or unsalable crops; local public reactions that may prevent a potential program from being developed and carried out, and most important to commercial applicators, the loss of working time because of conditions that will cause harmful drift. The control of drift is your responsibility!

You, as a commercial applicator, have legal liabilities. You can be fined up to $25,000 and sentenced to one year in prison for gross misuse. You may also face loss or suspension of certification. Additionally, smaller misuses and penalties can seriously hurt your reputation.

Almost any pesticide application will result in some drift, which can be serious or relatively harmless. Ideally you should work when there is no wind. Practically speaking this is not often possible. But, if there are sensitive areas downwind, i.e., homes, pastures, water, sensitive crops, etc., you can often arrange your schedule to treat the sensitive areas when there is little or no wind, usually in early morning or evening. Less sensitive areas can be treated when the weather conditions are not as good. The risk is less if the crop downwind calls for the same pesticide as the target, or if the area to be treated is located away from houses, streams, or other such areas. You can sometimes influence your clients to plant high risk crops in low risk areas. You simply must have the good judgement to stop treatments when conditions are too poor. Such action may save you money and your reputation.

The machinery you use will influence your drift problems. If you use granular applicators, generally you will not have a great drift problem (although broadcast application in high wind will result in a poor application pattern). Sprayers cause more drift than granular equipment and the amount of drift varies widely according to the type of sprayer. Power dusters are no longer widely used, one reason being the excessive drift that results from their use. You can reduce drift by setting your equipment correctly for a particular job. Remember:

- -- There is more chance for drift with airblast sprayers than with boom sprayers.
- -- There is more chance for drift with high pressure sprayers than with low pressure sprayers.
- -- Low volume concentrates are more apt to cause drift damage than high volume dilute mixtures.
- -- ULV sprayers present the greatest hazard for drift because the droplets are necessarily fine in order to get coverage.
- -- Smaller droplets drift further than larger droplets.
- -- The higher the boom or nozzle from the crop, the more chance for wind effect and drift.

If you keep these principles in mind you can operate your equipment to minimize drift.

When using airblast equipment, follow these practices to reduce drift:

- -- Direct nozzles with the airblast to give coarsest droplets that will be effective.
- -- Use lower pump pressures to give larger droplets.
- -- Determine the effective swath width and calibrate. Plan the spraying pattern of the field accordingly.
- -- Operate in little or no wind. Not only will wind cause drift, but it will distort the swath pattern.
- -- Choose a time to operate when drift is away from sensitive areas.
- -- When spraying near sensitive areas be sure the airblast is directed away from them.

When using boom equipment, follow these practices to reduce drift:

- -- Use lower pressures and spray discs with larger openings to increase droplet size. Using higher total volume per acre will allow larger droplets without reducing coverage.
- -- Choose the best type of nozzle. Hollow cone nozzles produce more "fine" droplets than flat fan nozzles. Newly developed nozzles are available that collect these "fines" together into larger droplets while they are still within the nozzle, thus reducing drift (fines can drift long distances).

- -- Keep booms mounted as low as possible to reduce wind effects. Use closer nozzle spacing and wider fan angles.
- -- Position boom to give larger droplets if ground speed is high (10 - 15 mph). Tilting the boom forward results in finer droplets; tilting backward gives larger droplets.
- -- Be sure sprayer is properly calibrated -- don't overdose.

Your choice of chemical and formulation has a significant effect on drift. Granules do not ordinarily drift very much because they are relatively large and uniform in size, although toxic dust can escape from some formulations. Dusts can drift badly because the particles vary widely in size and include a high percentage of small lightweight particles.

Many sprayers produce vast numbers of "fines". You can reduce fines by physical means - lowering pressure, using larger nozzles, etc. Materials called adjuvants that act as thickeners or foaming agents can be added to the spray tank. These materials increase the number of larger droplets and decrease the number of fine droplets. Some are simply added to the tank and others are pumped through special mixing pumps and/or nozzles. Sometimes the spray is thickened and other times it is made into a foam. All such adjuvants reduce drift by reducing the number of fine droplets, but no method makes a spray drift-proof.

In addition to actual particle or physical drift, certain materials vaporize, thus producing fumes which may cause damage for long distances downwind. These materials are "volatile" and include esters of 2,4-D, 2,4,5-T and other phenoxy compounds, dinitros, and some carbamate herbicides. Volatile forms can vaporize rapidly at 65 degrees F and high temperatures of 80 to 90 degrees accelerate vaporization of the volatile formulations and even low volatile esters of 2,4-D type herbicides. Amine formulations are usually considered non-volatile although extremely sensitive plants can sometimes be damaged. Obviously, you would choose an amine formulation rather than a high volatile ester in a sensitive situation. Spray on the coolest part of the day. Avoid high temperatures and low humidity.

## Contamination

Pesticides need careful attention even when they are intentionally placed on a target, placed in storage, located in a sprayer or on a truck. They often appear where they were not placed or wanted and thus cause problems.

Such places include our general surroundings (air, soil and water) and also our more intimate surroundings (equipment, storage, clothing, shoes) and even within our bodies. Some pesticide residue is purposeful, as when spraying a crop or applying a preemergence herbicide. Some is expected, like the residue in a sprayer; but some is unwanted and may be an inconvenience, contaminant, or hazard. Since your contact with pesticides is greater than that of the average person, you must be particularly careful not to over-expose yourself.

Every pesticide application that is made in the field will result in some air and soil contamination, which may be followed by contamination of water. The extent of this contamination will depend on several choices that you make. Your first goal is to keep the pesticide within the target area. (During some spraying operations more than 50% of the pesticide fails to reach the target and cannot be accounted for, except that it escapes into the environment). Secondly, you must consider drift, runoff, soil erosion by wind and water, volatility of the pesticide, persistence of the pesticide, plant absorption, use of minimum dosages, etc. All of these factors will be influenced by your choices of pesticide and formulation, application equipment, weather condition, filling practices, calibration and clean-up techniques.

You must choose the best pesticide: one that will give effective control, be persistent enough to do the job, yet break down when it is no longer needed. Pesticides usually persist longer in soils of high organic content than in light mineral soils. If you are working near water you can choose the pesticide least harmful to aquatic life that is registered for the use intended. Certain herbicides depend on persistence for effectiveness and can cause problems if susceptible crops are planted too soon in the treated area. Many of the chlorinated hydrocarbons -- DDT, dieldrin, aldrin, etc., were highly effective, but so persistent and accumulative that their use has been drastically cut back or prohibited. The choice of pesticide also includes choice of the best formulation. The applicator wants the pesticide to stay within the area treated. Therefore, he will use the formulations that will be less likely to cause drift and may use anti-drift adjuvants.

Even though the pesticide remains in the treated area, it would be wise to check the fences and notify the owners if livestock graze nearby. You should also warn your client about any restrictions on grazing or feeding of the treated crop, so that no poisoning of livestock or contamination of meat or milk results. You may wish to use a less toxic or less limited pesticide if working near livestock.

Here are some tips that you may follow to improve your operation and cut down on local contamination. 1) How do you carry your pesticides and other supplies in your truck or trucks that service your sprayers? Rather than riding loose in the back of the truck they should be enclosed. Built-in lockers are convenient if you can get them, but a locked storage chest will be adequate. 2) You also need a place to hold the empty containers that you don't burn in the field. 3) A first aid kit in the cab of the truck can literally be a life saver. Plastic eyewash bottles that have a flushing action can also be carried in the cab. 4) A container of clean water fastened somewhere on the outside of the truck with detergent and hand cleaner nearby is also worthwhile for washing off spills, splashes or other skin contamination. A faucet or valve on the container will make it easy to control water flow.

5) If you transport pesticides over the highway to sprayers in different locations you may accidently spill concentrates on the highway. Keep a shovel, stiff broom, and neutralizers (Clorox, lime) on your truck. Don't forget to call local police and health officials if the spill is too large for you to handle safely yourself. 6) You should have boots, gloves and a respirator handy if the pesticide you are carrying and applying is toxic enough to require them. This same equipment can also be used for spills of concentrated pesticides in the field.

7) Are you filling from a well? Who else is using it and for what purpose? Use a separate pump with check valves to prevent back siphonage and be sure the filler hose does not dip into the sprayer tank. If you mount the right size hook to hold the filler hose, you won't have to hold it and there will be no chance of its dipping into the tank. Be sure your sprayer doesn't overflow and drain pesticide contaminated water back into the well. If the well you are using is the source of domestic water or for watering cattle, you may want to fill elsewhere. Even if you fill elsewhere, you should take the same precautions (cattle drink from ponds and fish live in streams).

Suppose you do contaminate the well. What then? First, contact your county or state health official. Usually your actions will depend somewhat on the toxicity of the pesticide involved and how tightly it fastens to particles in the water and on the walls of the well. With materials of low or moderate toxicity, the well should be pumped dry, allowed to recover and pumped again. Addition of a charcoal slurry will help absorb the pesticide. Clorox or another chlorine compound may help break down the pesticide. The well should be pumped dry after the addition of any of these absorbents or neutralizers. Domestic and barn plumbing should be thoroughly flushed after the well is decontaminated and before any water is used. If the contamination was of highly toxic materials, a chemical test should be made before the water is used. If the well cannot be purified you may be liable for a new water supply. Prevention of contamination may be vital to your business.

8) Your sprayer filling station can be designed to minimize problems. Frequently filling stations are on pond or stream banks and the natural flow is back into the water. Grading the area to slope away from the water will prevent this problem and allow you to neutralize an unplanned spill so that it does no damage. 9) Another common problem with these areas is disposal of "empty" pesticide containers. Much too often they end up in the water. A trailer, old truck van, or some other storage place, in which used containers can be held safely for disposal, will prevent this contamination.

10) There are two main possibilities for contamination at your storage and clean-up area: chemically contaminated runoff from wash water or fire fighting water, and exposure to yourself or other people. Your core manual tells you how to avoid runoff problems. 11) The right precautions will help you avoid exposing yourself during clean-up or repairs. Dress properly for clean-up as well as for mixing or application. The residue that you scrub off the outside of your equipment may be more concentrated and toxic than the spray itself. Don't scrub the surface with your bare hands or a rag which will soon be loaded with the chemical. Instead use a scrubbing brush with a handle and, if necessary, rubber gloves. Check the label if you are in doubt.

12) Often you need to clean and check your sprayer booms, hoses and nozzles when there is spray material in the tank. Rather than use contaminated

water from your tank you can hook a hose to the discharge side of your spray pump and do your cleaning with uncontaminated water from your domestic water supply. This is particularly convenient if your spray tank has spray mix in it. Remember, however, that the first discharge from the nozzles will be spray mix. Remember also that back siphoning can occur even in pressure water systems if there is a sudden heavy drain on the system.

13) Normally, you will not get inside your spray tank. However, you may have to make repairs that require you to do so. If so, remember that it is probably a highly toxic area. Avoid working alone. Wear full protective gear to prevent both dermal and inhalation toxicity. Even outside the tank welding may generate highly toxic fumes. Use a respirator.

14) Personal contamination or poisoning can also be caused by lying on contaminated ground while making repairs to machinery. Move the equipment to an uncontaminated area, or use a creeper, piece of linoleum or something similar to protect yourself.

As in other areas of pesticide handling, the best preventative for contamination is your own awareness and good judgement.

## Specific Use Problems

Some categories of pesticides have special problems that require your attention over and above the usual awareness.

Herbicides and their use are growing rapidly and now represent the largest single group of pesticides used in agriculture. Although, as a group, they are relatively low in their hazards to humans and to wildlife, they are not without hazard, and some are highly toxic. However, it must be remembered that the greatest hazard associated with herbicides is their phytotoxic effect on non-target plants caused by incorrect or inaccurate application. Misapplication of herbicides may occur as a spray drift of droplets, particles, or vapor, as soil contamination resulting in absorption by roots of non-target plants, as excessive soil persistence causing injury to later crops, and as sprayer contamination. All must be avoided!! All produce obvious damage but by the time they are visible it is too late to remedy the cause.

Plant growth-regulating or hormone-like herbicides produce the greatest hazard to non-target plants. Although these chemicals are primarily used to check growth of broadleaf plants, crops such as wheat, oats, barley, milo, corn and turf grasses can be seriously affected as well.

Spray drift of soil-applied non-crop herbicides such as fenac or 2,3,6-TBA can injure sensitive crops such as beans, even when the drift has occurred before planting. All herbicides are subject to drift for considerable distances. Some, however, such as those listed below present a particular hazard to non-target plants from drift. All of them except dinoseb, propanil, and paraquat are of the plant growth regulator type and can cause abnormal plant growth even in trace amounts.

EXAMPLES OF HERBICIDES THAT PRESENT A PARTICULAR HAZARD
TO NON-TARGET PLANTS FROM DRIFT

2,4-D
2,4-DB
dicamba (Banvel)
dichlorprop (2,4-DP)
dinoseb
fenac
MCPA
MCPB
mecoprop (Mecopar)
paraquat
picloram (Tordon)
propanil (Stam F-34, Rogue)
silvex
2,4,5-T
2,3,6-TBA (Benzac, Trysben)

Sprayer contamination is also most likely to result from the materials listed above. If the sprayer is used for other purposes, decontamination is a problem. Repeated flushing with water is not a dependable method to remove herbicide residues from any spray tank, pump, hose, boom and by-pass system. Emulsifiable formulations such as esters and oil soluble amines are more difficult to remove than water soluble metallic and amine salts. Wooden tanks are almost impossible to decontaminate. If you must decontaminate, circulate a solution of household ammonia or detergent (1 quart to 25 gallons of water preferably warm) through the sprayer at operating pressure, including hoses, booms, and nozzles. Let stand for several hours, drain, flush, add more water. Test by spraying sensitive plants such as bean or tomato seedlings. Injury will usually appear in 2 to 7 days if the sprayer is still contaminated.

Soil persistence of herbicides is important in selecting an herbicide. You must consider the crops that will follow if problems are to be avoided.

Soil persistence is dependent on many factors including rate, formulation, and method of application of the herbicide, as well as soil type, microbial populations, soil temperature, moisture, and tillage. In general, herbicide breakdown is most rapid in warm, moist soils with good microbial growth; it is more prolonged by cold, dry, sterile soils. Alachlor, butylate, endothall, TOK, paraquat, and silvex are a few examples of some herbicides with relatively short soil persistence (1 to 2 months) based on weed control. Materials like atrazine, benefin, bromacil, dicamba, diuron, picloram, terbacil and trifluralin are examples of herbicides persisting for six months or more.

## Special Use Pesticides

Growth regulators, desiccants, and defoliants are chemicals that can be used to improve crop performance, production, storage or handling procedures, rather than to control a particular pest. Slight variations in the methods of use of these chemicals can have significant effects on their performance: the same chemical may produce different or even opposite effects on the same crop, depending on the rate of application and weather conditions, as well as differences in age, stage of development, rate of growth, and vigor of the plants.

## Growth Regulators

Growth regulators may be used in very small amounts either to stimulate or to reduce growth, flowering, or fruiting. They are used in the production of fruits and nuts, vine and small fruits, vegetables and field crops. Materials such as napthalene acetic acid (NAA), napthaleneacetamide (Amide), naphthylpthalamic acid (NPA), and carbaryl, when applied after bloom for blossom thinning, upset the physiology of the flower or fruit causing the seed to die and the fruits to drop from the tree. Other materials such as dinitros, used in bloom, are caustic and burn some of the flowers off. Some growth substances may be used to improve fruit set, prevent excessive fruit drop, or to control the time of fruit maturity. Other materials have been used to increase bloom the following year. Because of the sensitivity of plants to these chemicals and the small quantities used, extra precautions must be carefully observed to use precisely the right amount of chemical at the right time on the specific varieties intended for treatment. In these applications equipment calibration is vital. Application is usually made as a foliar spray, a soil drench or by bark injection. Particular care must be taken to avoid drift with foliar sprays and timing is usually critical.

Sprout inhibition is another form of growth regulation, in which chemicals are applied to crops such as potatoes and onions to prevent sprouting in storage. Inhibitors should not be applied to potatoes or onions intended for use as seed. Treatments may be made in the field prior to harvest (i.e., maleic hydrazide to potatoes or onions) or in storage after harvest (Chloro IPC as a dip or spray during grading or as a vapor or aerosol applied in the ventilation system of the storage).

Growth regulators also include chemicals which break dormancy in plants or plant parts, and speed up root formation and elongation. This category does not include fertilizers and plant nutrients although they are sometimes sprayed on crops -- particularly fruit trees. Do not combine fertilizers or plant nutrients with pesticides.

## Desiccants and Defoliants

Some chemicals are used to cause the leaves to drop from crops such as cotton, soybeans, or tomatoes to make harvest easier without killing the plants. Such chemicals are called defoliants. Other chemicals, desiccants, are intended for speeding up the drying of plant parts to aid in the harvesting of some seed crops (alfalfa, clover, sorghum), potatoes, dry beans and nursery stock. Frequently the terms are used interchangeably and depending on the amount applied some defoliants also act as desiccants. Sometimes mixtures are used (i.e., cotton) and these combination materials are called "harvest-aids".

Some of the advantages of using defoliants or desiccants are: 1) reduction of disease or insect populations, 2) killing of weeds which interfere with harvest, 3) aid to and simplification of mechanical harvesting, 4) quality improvement, 5) reduction of storage crop disease, 6) reduction of the moisture content of seed, and 7) yield increases. Disadvantages may be: 1) a reduction in yield and quality, and 2) toxic residues.

Complications can result from the use of these materials, so you must take great care in their selection and use. For example, the use of some materials on potatoes causes discoloration at the stem end of the tubers.

Other materials cannot be used on potatoes that are to be stored without increasing the risk of storage rot. Slower kill of the vines may be preferable to a faster kill. Other factors such as soil moisture, cultural or climatic conditions, stage of growth (flowering plants are not easily desiccated), and stage of maturity are important considerations. Be sure you have all the information needed before using any of these materials. Injury is readily visible, even if minimal. If additives are specified on the label, use only those recommended. Crops treated with a desiccant generally cannot be used for grazing, and many do not permit use of the seed for food, feed, or oil purposes. Before using a defoliant or desiccant on a crop, be sure that the remaining part of the crop is not going to be used as food or feed.

## Soil Pesticides

The soil is the most complex medium you will treat for the control of pests. Soil treatments include the use of variously formulated insecticides, fungicides, nematicides, and herbicides. Success in soil pest control requires: 1) knowledge of the pesticide: volatility, water solubility, absorption rate and rate of breakdown; 2) knowledge of the characteristics of the soil being treated: sand, silt, organic matter content, texture and structure, temperature, moisture content, and air movement; 3) requires knowledge of the pest: its stage of development and its susceptibility to pesticides. An understanding of these factors and how they relate to each other is essential.

Soil pesticides can be grouped in two categories -- volatile and non-volatile.

### Volatile - Fumigants

Those that are volatile are called fumigants. They vary from broad-spectrum materials to those that are very specific; from those having very short residual effectiveness to those with longer residual effectiveness; and those which are highly volatile to those having low volatility. Some are available under pressure as liquids but are released as gasses under covers (tarpaulins). Others are liquids but vaporize after being placed in the soil.

The dose of a soil fumigant necessary to kill pests depends on the concentration of the chemical in the soil and the amount of time the organism is exposed. This is influenced by soil conditions -- soil type, moisture level, etc. Recommended rates are selected to perform satisfactorily over a wide range of soil conditions.

The effectiveness of chemical treatment also depends upon the temperature and moisture of the soil and the depth to which it is treated. If the soil is too warm or too dry and the fumigant injected too shallow, six inches or less, the gas may escape too fast for good control; and if too cool, diffusion may be too restricted to obtain good control. [If too wet, the water occupies most of the air space, more fumigant dissolves in the water, the fumigant that is left as a gas moves very slowly, distribution is poor, and control is poor. Soil fumigants perform best when soil is only moderately moist, somewhat drier than seedbed condition, and the soil temperature is between 50° and 80°F. Frequently a fall treatment provides better results than a spring treatment because of more favorable temperature/moisture relationships in the fall. The fumigants should be injected deeper than six inches. The soil surface should be sealed by some effective method of soil compaction.]

Soil structure and condition also influence the effectiveness of fumigants. Generally fumigants move faster in loose and sandy soils than in clay or compacted soils. Control will be better in well-tilled soil with high content of organic matter than in poorly-prepared cloddy soil. Highly organic soils may absorb or "tie up" the fumigant, and soils with plant residues (stalks, vines, etc.) may protect nematodes and other pests from the fumigant, as well as reducing effective injection and seeding.

Aeration time (the time needed to allow the fumigant to leave the soil) is important to avoid injury to the crop. It varies with the chemical, soil temperature, moisture, texture, and the crop to be planted. Fumigants such as ethylene dibromide, methyl bromide, and dibromochloropropane (DBCP), leave appreciable residues of bromine in the soil. These residues are toxic to some plants (onions are very sensitive) and are taken up by others (many forage and feed crops). DBCP causes severe damage to tobacco, potatoes, sweet potatoes, garlic and some types of pepper.

Some fumigants applied under tarpaulins may reduce the nitrifying bacteria populations of the soil and therefore, nitrate fertilization is required following treatment to correct this condition.

## Non-Volatile - Non-fumigants

The non-fumigant soil pesticides are non-volatile and vary in their characteristics: from high to low water solubility; from non-systemic to systemic in their activity; and from little (short residual) effectiveness to long (residual) effectiveness.

Non-systemic pesticides must be directly placed on the site of action (carried by water for instance) or must depend on the plant to grow to the material. Pesticides having systemic action may be translocated upwards or downwards through the plant, or in both directions; therefore, it is not necessary to apply the pesticide directly to the part of the plant to be treated.

Non-fumigant soil pesticides are usually dependent upon the presence of soil moisture. Moisture is often needed to activate or release the pesticide, to move or distribute it into or through the soil, and to allow absorption into the plants. Materials that are highly water soluble need less water than products of low solubility in water. Those materials having low water solubility, high evaporation rates, sensitivity to breakdown by sunlight, or high absorption rates on soil particles, usually require mechanical incorporation (physical mixing) into the soil, regardless of rainfall or irrigation.

As with fumigants, non-fumigant soil pesticides are less effective or require higher rates of application in soils high in organic matter, in fine clay or silt soils, and at temperatures less than optimum. Best results can be obtained if you know the soil type and organic matter level of the fields you treat. For future jobs, keep records of materials and the results obtained.

## Safety

Pesticides vary in potential toxicity to the applicator and the environment. The fumigants are generally classified as moderately toxic, whereas the non-volatile pesticides range from extremely toxic to relatively non-hazardous. It is important that the toxicity of each pesticide be known before use. The label will tell you, but in the absence of such information, any pesticide should be considered extremely toxic. Proper safety equipment and clothing should be worn when highly toxic pesticides or pesticides of unknown toxicity are being used. Likewise, potential environmental pollution should be recognized, and proper precautions taken. Again, the label will warn of hazards, and list the precautions that should be taken.

## Combinations or Mixtures of Pesticides, Mixing and Compatibility

Mixing pesticides in the spray tank is an old and widely used practice. A mixture of an insecticide and fungicide or an insecticide and an acaracide is often used on fruit and vegetables to save an additional application. Different herbicides are sometimes mixed to broaden the spectrum of activity. A grass killer may be combined with a broadleaf killer, or a product particularly effective against one particular species may be added to another of more general activity to broaden the spectrum of effectiveness. This is practiced with insecticides as well as with herbicides. Sometimes a mixture of products is used to increase effectiveness against a single pest species. Many of the newer pesticide labels specifically list the mixtures that can be made with that pesticide.

Under present federal regulations, uses of pesticides inconsistent with (or not mentioned on) the labeling are a misuse and unlawful. The legislative history shows, however, that it was the intent of Congress that EPA be reasonable in interpreting and enforcing misuse provisions. Accordingly, EPA has interpreted the legality of tank mixing of pesticides and set a policy that will be in effect until modified by further statements or regulations.

Tank mixes may fall into one of three acceptable categories:

### Category 1 - Instructions provided on label

instructions for tank mixing are provided on one or more labels of EPA registered products. Such uses are fully consistent with the label and no further clarification is needed.

### Category 2 - Registered intrastate

tank mixes are covered by state registrations. Such registrations are valid until replaced by EPA registrations scheduled to be completed by October 1976. If a product use is cancelled or suspended from interstate commerce at the federal level before such time, the state registration is also cancelled. To date the only products involved are DDT, aldrin and dieldrin. Otherwise state use registrations are valid.

Category 3 - Recommended by state agencies or with a history of use

tank mixes have been tested and recommended by cooperative extension, state agricultural experiment stations, state departments of agriculture, or are recognized as common agricultural practice. These are acceptable provided the dosage rate of any pesticide in the mix does not exceed the label instructions for the same product used singly, and provided that the label does not specifically instruct against such a mixture.

EPA has not reviewed those uses in Categories 2 and 3. While such uses are legally acceptable as to consistency with label instructions, this does not mean that EPA has approved them in regard to either efficacy or human and environmental safety data. Therefore the user applies them at his own risk.

If adverse effects are observed from any particular tank mix EPA may consider these uses on a case-by-case basis and rule them inconsistent with the label.

In summary, tank mixes and serial applications are ruled consistent with the label and recommendable if:

a) the label specifies such uses,

b) there is a state registration for such uses, or

c) such uses are recommended by state agencies or are common agricultural practice.

Even when pesticides are approved for use in a mixture, problems may still result. Formulations of a particular pesticide vary from one product to another, and incompatibility may result from the different wetting agents, solvents, and other additives in them. Liquid formulations are particularly susceptible to incompatibility problems due to the many additives they usually contain. Incompatibilities are expressed in different ways, but a crystalline precipitate or a gelatinous mass is common, which would require time to clean out plugged nozzles, screens, and regulators. Another common result is a break in the emulsion in which the different ingredients separate out as would oil and water. This is the result of the emulsifier being destroyed, and spray injury is likely to result. Sometimes the addition of soluble salts to the spray tank will cause an emulsion to break. Separation can also take the form of clumping of particles together. This is called agglomeration.

Incompatibility can also result in lessened activity of the combination although no visible problems can be seen. The combined materials inactivate one another, and the resulting mix will be less effective.

Hardness of the water may also affect a pesticide or mixture of pesticides. Phosphate and carbamate materials are more susceptible to high alkalinity than other pesticides. The addition of lime, lime sulfur, Bordeaux mixture or other highly alkaline materials may cause decomposition, loss of toxicity, or phytotoxicity.

Combinations of oil or petroleum solvents with organic chemicals frequently are very injurious to plants. Many emulsifiable concentrates are formulated with petroleum solvents and fall into this category. When two emulsifiable concentrates are combined, the pesticides may be compatible but the solvents or emulsifying agents may not be and injury may result.

Many cases of incompatibility are reported for combinations of emulsifiable concentrates and wettable powders. Sometimes one or both pesticides precipitate or fall out of the mixture and spray injury to the crop is the frequent result. In other cases, mixing may cause excessive residues although no precipitation is noticeable in the tank.

Most agricultural emulsifiable sprays are oil-in-water emulsions producing small particle sizes. Invert emulsions, water-in-oil, are usually less desirable for insect and disease control but, because of the larger droplets, may be more desirable for herbicides. When difficulties in emulsifying an oil- or pesticide-in-water spray are encountered, they can usually be corrected by starting with just enough water to cover the agitator, then starting the engine and running the agitator and the pump at full pressure to force the liquid through the by-pass return to the tank. If an additional or separate emulsifier is to be used, it should be added to the tank before adding the pesticide or oil. Allow the pump to run for two or three minutes. Once this emulsion is formed, add the rest of the water to fill the tank while the pump and agitator are running. Invert emulsions usually require special equipment in which a special mixing chamber is used between the pump and the nozzle.

Although incompatibility may still be a problem, it can frequently be reduced to the minimum by:

1) Using formulations produced by the same manufacturer.

2) Keeping the equipment clean and well drained.

3) Never putting pesticides in an empty tank. The tank should always be partially filled before adding the pesticide.

4) Never combining concentrates, but diluting them first.

5) Mixing wettable powders with water to form a slurry before they are added to the tank (unless you have an inductor system).

6) Adding wettable powders to the tank before the emulsifiable concentrates.

## Mixtures of Pesticides and Fertilizers

Many of the principles for using tank mixtures of pesticides also apply to fertilizer-pesticide mixtures. The most important point to remember is that such mixtures, either wet or dry, should be handled as pesticides, not fertilizers. In some states there are specific regulations governing use of fertilizer-pesticide combinations. Check your local state situation, or if you cross state lines -- make sure you are operating within regulations.

Pesticides are precision tools. The total quantity of a pesticide in the tank may be less than the accepted variation in fertilizer application which may vary from a plus or minus of 10 to 15 pounds per acre. Timing, placement, and distribution are frequently different for pesticides and fertilizers. Compromising one requirement may limit the usefulness and safety of the mixture.

Where tank mixtures are to be used, make sure that agitation is adequate to maintain the suspension. Suspensions also require about one to two gallons of spray carrier for each pound of product to be suspended. Some products are specifically formulated for use in fertilizer mixtures. Others specify the need to check emulsion stability and add a compatibility agent if needed.

## Serial Applications of Pesticides

Serial applications of pesticides are applications in which the pesticides are applied individually but following one after another. Although the time is generally limited to a few days, it can be longer. Regulations governing serial applications are the same as for tank-mixtures of pesticides. Problems arising from incompatible serial applications may be plant injury, loss of effectiveness of one or both pesticides, excessive residues, etc. This is particularly true if oil is applied before or after a pesticide or nutrient spray.

## Adjuvants or Spray Additives

Pesticides, whether emulsifiable concentrates or wettable powders, are formulated for general performance purposes under average conditions. For many jobs they perform satisfactorily, but there are also many situations where they fall short of the desired effect. For example, in very hard or soft waters, a formulation may have too little or too much emulsifier, with the consequent problems of difficulty in mixing or of excessive foaming. A formulation may evenly distribute a pesticide on the leaves of crops such as beans and potatoes satisfactorily, but on the waxy leaves of cabbage, cauliflower, or onions, the spray, instead of spreading as an even film over the leaf surface, may form small, round droplets. It then runs off of the plant and onto the ground, leaving no deposit to protect the plant. The addition of a surfactant to the spray tank will solve this problem. Recently it has been common to add to herbicides materials which improve their effectiveness by increasing their ability to wet and penetrate treated surfaces. A substance added to the spray mixture to aid or improve the performance of the main ingredient is an adjuvant.

Adjuvants may be added to the spray mixture to:

1) Improve the wetting of the foliage or the pest.

2) Change the evaporation rate of the spray.

3) Improve the ability of the spray deposit to resist weathering.

4) Improve the penetration, absorption and translocation of the pesticide.

5) Adjust or buffer the pH of the spray solution increasing the effectiveness and longevity of alkaline sensitive pesticides.

6) Improve the uniformity and amount of the deposit.

7) Improve the ease of mixing or compatibility of the spray mixture.

8) Increase the safety from spray injury to the crop.

9) Reduce the drift hazard to neighboring crops.

10) Improve physical properties of the mixture -- i.e., anti-foaming agents.

Depending upon their intended use, adjuvants are called emulsifiers, wetters, stickers, extenders, spreaders, deposit builders, film formers, buffering agents, thickeners, penetrants, foaming agents, anti-foaming agents, etc.

Adjuvants are highly active materials. In most cases, a very small quantity will have great effect. You should be careful to use only the amount recommended. Too much adjuvant may be just as bad as too little -- it makes little difference whether the pesticide runs off the foliage because it balls up or because it forms too thin a film on the foliage. Also, too much adjuvant may cause herbicide spray to lose some of its selectivity and injure plants normally tolerant of it.

Regulations require spray adjuvants, for use with pesticides, to be registered and carry an EPA number and either to be exempt from the requirement of a tolerance or to have a tolerance established.

Proper selection of the adjuvant for your job is of the utmost importance.

## II. PESTS

You can't solve a pest problem if you don't know the pest. Accurate diagnosis of the pest and its damage is essential in deciding what to do. If you are familiar with the pest you may decide to do nothing, because you know that most of the injury has already occurred, that the potential damage is less than the cost of chemical treatment, or that no effective chemical treatment is available. Additional damage caused by driving equipment through the crop may be greater than that caused by the pest. For further discussion on specific pests refer to the chapter in this manual that deals with your commercial category.

### Identification and Diagnosis

Identification of the pest or pest damage is the most important step in controlling the problem. Thorough knowledge of the crop and its growth characteristics is essential. Otherwise, evidence for the presence of and damage by a pest may go undetected. To know and to recognize the causes of poor plant growth and the signs of pest injury require years of experience. This is one reason why people who diagnose pest problems prefer to work with a small number of commodities such as vegetables, forests, or turf. Even then, there is no substitute for experience; the accurate diagnosis of plant ailments is a skill requiring much time and effort to develop. Generalizations can be made, however, that will help identify the cause of some ills of plants.

Plants may be injured by animals such as insects and rabbits, by other plants (weeds), by fungi, bacteria, viruses and mycoplasmas, by environmental imbalances such as drought and nutritional deficiency, and by chemical injury such as air pollutants and sprays (see below).

Possible Causes of Injury to Plants

| Animals | Other Plants | Microorganisms | Other |
|---|---|---|---|
| Birds | Dodder | Bacteria | Air pollutants |
| Dogs | Mistletoe | *Fungi | Drought or excessive moisture |
| Insects | Moss | Viruses | Lightning, wind & hail |
| Mites | Weeds | Mycoplasmas | Mechanical injury |
| Millipedes | Algae | Viroids | Mineral deficiencies |
| Nematodes | | | Spray injury |
| Rabbits, mice, moles, rats & others | | | Extreme temperature |
| Slugs and snails | | | Oxygen deficiency in soil |

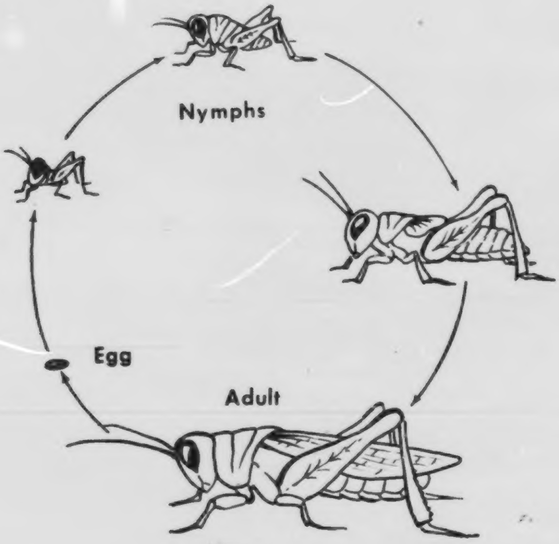
*Some fungi may be large in size.

The cause of damage is often revealed by careful observation. For example, a canker disease may have girdled a twig or limb causing the leaves to wilt or die. However, one must not only look at the leaf, but one must look carefully along the twig or limb to find the cause. Or, an insect may be eating the plant roots -- the symptoms first appear on the leaves, but until the roots are examined, the cause cannot be correctly identified. With careful observation, knowledge of the plant's history, and a general knowledge of possible causes within the geographical area, plant ills can frequently be diagnosed without the need of a specialist.

Possible and correct diagnosis of the problem is essential for effective control. Identification of pests is based on a thorough knowledge of the host and symptoms of damage, the part injured, time of year, etc. Identification of damage by location and host will be given in this manual following a brief treatment of some characteristics of the different pests.

## 1. Insects

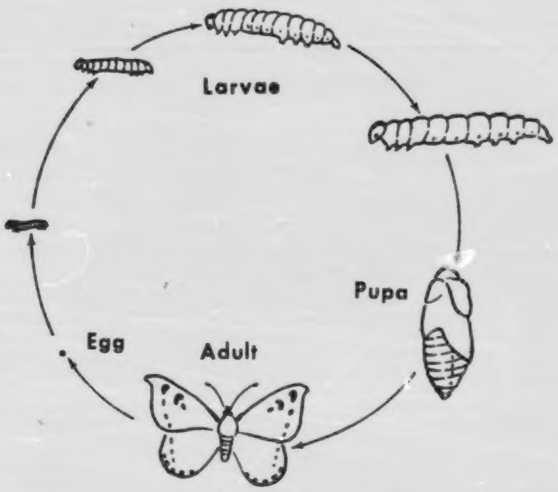
Most insects injurious to plants have a life cycle in which either: 1) the newly hatched insect differs from the fully grown adult primarily only in size -- the young or nymphs look like the adults in form, except that the wings may not be developed, and they feed in the same places (see illustration below):



GRADUAL METAMORPHOSIS

Insects with gradual metamorphosis change shape gradually. Wings develop externally and as growth takes place, the nymphs look more like the adult.

or 2) the adults and young are not alike -- the young or immature forms are wormlike, usually called larvae or caterpillars, while the adults are moths, butterflies, flies or beetles (See illustration). The damaging stages of insects with this type of life cycle are most often the larvae which may be found when the adult stage cannot. Many times insects found on injured plants are not the primary cause of the injury, they just happened to be there.



COMPLETE METAMORPHOSIS

Insects with complete metamorphosis go through four stages of growth. None of the young looks like the adult. There is a great change in shape when the adult emerges from the pupal stage.

Ways Insects Injure Plants

a. Chewing: Insects with chewing mouthparts usually leave obvious feeding wounds such as notched leaves, tunnels or wounds in wood, bark, roots, stems, fruit, and seeds, or mining in the leaves. Symptoms: ragged leaves, holes in wood and bark or in fruit and seed, serpentine mines or blotches in leaves, wilted or dead plants, or presence of "worms".

b. Sucking: Some insects with sucking mouthparts may not leave obvious feeding wounds since they puncture the leaf or fruit to suck out the sap and cell contents, and to inject toxins into the plant. Symptoms: leaves usually off-color, evidence of scorch or hopper burn, wilted or misshapen foliage and fruit.

c. Oviposition: Scars can be formed on stems, twigs, bark, or fruit as a result of injury during egg laying. When certain insects have laid eggs in parts of plants, galls may form as the young insects develop. Galls are growths that resemble tumors and may form on leaves, twigs, buds, and roots. They disfigure plants and some may cause serious damage.

d. Vectors of diseases: Insects may carry plant pathogens on their body or inject them with the mouthparts while feeding from plant to plant, e.g., elm bark beetle - Dutch elm disease; various aphids -- virus diseases; bees -- fire blight. Symptoms: leaves wilted, dwarfed, foliage off-color.

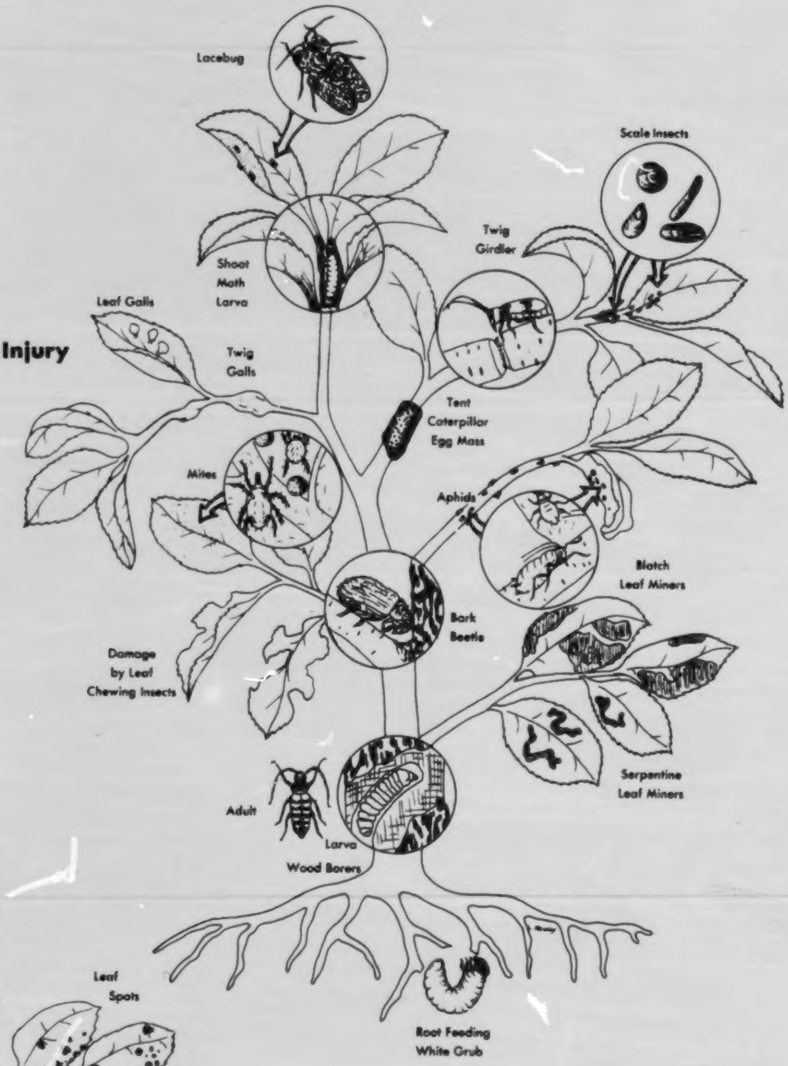
e. Excretions: Honeydew deposits secreted by some insects lead to the growth of sooty mold (a black fungus), and the leaves are unable to perform their manufacturing functions. This results in a weakened plant. Symptoms: sooty black areas on leaves, twigs, branches, and fruit.

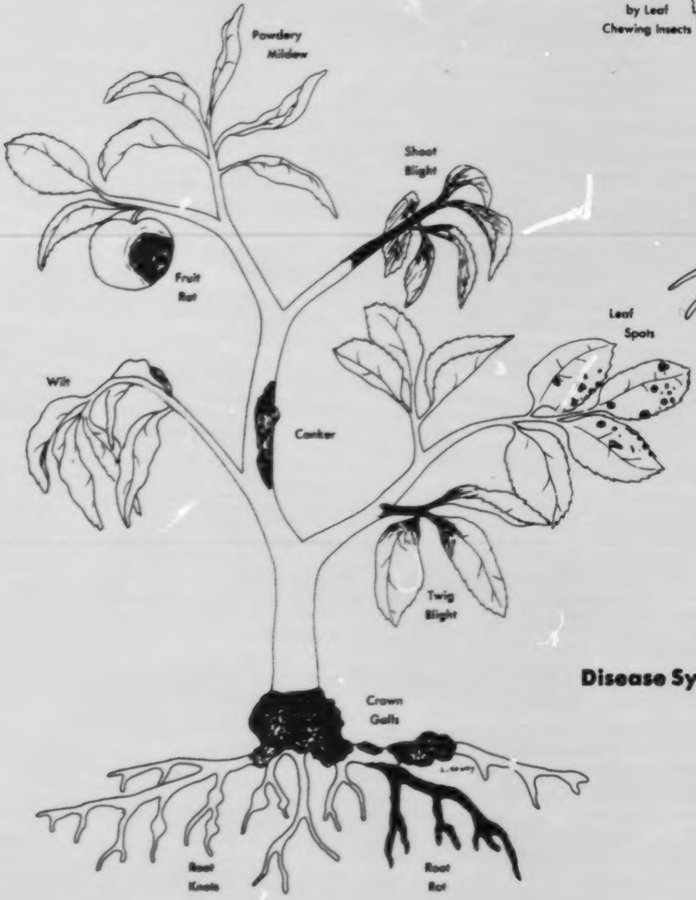
## 2. Diseases

Unlike insects you cannot always see the organism which causes the disease. You can see the signs and symptoms of its presence but in the early stages these may be difficult to identify. Some diseases are caused by non-living agents such as air pollution, drought, etc., and are called non-infectious plant diseases. Living causal agents are called pathogens and cause infectious plant diseases. Sometimes they can be easily recognized with the naked eye. However, in most instances you cannot see the pathogen without the use of a microscope. You see only the symptoms. Knowledge of the host plant, its diseases, and signs or symptoms are very important in identifying them in the field. Prevention of further spread of a disease is a primary concern. Once infection occurs, favorable moisture (rain, dew, etc.) and temperature conditions may cause rapid spread and damage. Leaf spots and shoot

# Ways In Which Insects And Diseases Injure Plants

**Insects and Injury**





**Disease Symptoms**

blight may spread very quickly under favorable conditions, while wilts and root rot diseases may spread more slowly. Early and accurate diagnosis is vital to successful control.

## Ways in Which Infectious Diseases Damage Plants

a. Disrupt water-conducting cells and plug the vascular system which conduct food and water throughout the plant. Symptoms: yellowing, wilting, dead branches.

b. Destroy or damage cells of leaves and sometimes fruit. Symptoms; blotch, scab, black spots on leaves, fruit rot.

c. Destroy or damage roots and root hairs. Symptoms: wilting, yellowing or stunting of plants, rotted roots, death.

d. Cause formation of galls and overgrowths. Symptoms: unusual growths on flowers, twigs, and roots.

e. Decay of wood.

f. Damage to flowers, fruit and seeds causing them to rot. Examples: fireblight, bacterial rot of potato.

g. Damage or death of plant tissues from production of toxins.

## 3. Nematodes

Nematodes are very small roundworm-like animals, whose young resemble the adult except for their smaller size. Those which damage plants live in the soil and are round, thread- or eel-like worms which are so small that they canNOT be seen without the aid of a microscope. Many types of nematodes cause no damage, but others feed on or in the roots, bulbs or stems, or on the leaves or seeds of plants. Special training is necessary to identify them. Symptoms of disease caused by nematodes are usually localized in one or more spots in a field or turf area, but the nematodes involved must be isolated, identified, and numbers estimated before the symptoms can be accurately evaluated. An examination of plant roots and soil taken from around the roots can help determine whether nematodes are wholly or partially responsible for poor plant growth.

## Ways in Which Nematodes Injure Plants

a. Mechanically disrupt water conductive tissues or induce cell abnormalities resulting in inefficient translocation of water and nutrients. Symptoms: wilt, loss of color, yellowing of leaves.

b. Destroy or damage roots and root hairs. Symptoms: stunted growth, poor vigor; roots with necrotic spots or dead root tips and/or stunted roots, or loss of feeder roots.

c. Causes gall formations on plant roots which will reduce vigor in the plant. Symptoms: root galls -- be careful not to confuse with nitrogen fixing nodules on legumes.

Nematode population levels for preplant treatments have limited meaning. Knowledge of their damage to previous crops is more useful. Usually the combination of one or more of the following factors are necessary to cause economic damage.

1. Optimum conditions for nematode build-up.
2. Plant stress conditions.
3. Nematode disease complexes.
4. Root or tuber quality (root crops).

The principle nematodes and crops of economic importance are as follows (there is considerable variation in species and host specificity):

| Nematodes | Crops |
|---|---|
| Root-knot | A very wide economic host range (numerous species and specificity). |
| Root lesion | Most crops, but especially perennial crops. |
| Cyst | Sugar beets, crucifers, soybeans, potatoes, cereals, rice (species and strain specific) |
| Citrus | Grape |
| Ring | Primarily perennials |
| Dagger | Primarily perennials |
| Sting | Corn, sorghum, and grasses |

For further information on specific nematode problems contact your local Cooperative Extension agent for the necessary information.

4. Weeds

Familiarity with two major groups of weeds, narrowleaved weeds and broadleaved weeds, is important in selecting the proper herbicide.

Narrowleaved weeds include all grasses, sedges (nutsedge), rushes, bulrush, cattails and many other plants. All have leaves with parallel veins and are easily recognized (monocots).

Broadleaved weeds is the larger group of the two and includes mustard, dock, smartweeds, pigweed, purslane, field bindweed, blackberries and many others. The veins in the leaves of this group are not parallel but are net-like (dicots).

Ways in Which Weeds Injure Plants or Affect Land Use

a. Reduce yields -- competition for moisture, light, nutrients.

b. Reduce crop quality -- weed seeds, dockage, weeds in hay, straw, etc.

c. Increase production costs -- additional tillage, cultivation of nursery crops; prolong precommercial period in plantations.

d. Increase labor and equipment costs -- machinery wear and tear, etc.

e. Insect and disease carriers or hosts -- e.g., wheat stem rust, corn borer, pine needle rust, and numerous viruses.

f. Poisonous or irritating to animals or people -- cocklebur seedlings, poison ivy, hay fever, etc.

## Collecting Specimens for Identification

If you are unable to identify the pest or the damage from the information you have, you may have access to an authority who can come to the field to identify the damage or pest. If this is not possible, you may wish to collect a sample to send him. No matter how much experience you have had, some problems will require further investigation and you will want to collect specimens. Directions for sampling and shipping are available from your local Cooperative Extension agent.

## Economic Considerations

Economic injury levels depend on the amount of damage that can be tolerated rather than on pest population levels. In some instances the presence of even a small pest population may result in too much damage, while in other cases extensive populations may not cause significant injury. Sometimes the pest is very conspicuous, but may not be affecting crop yield or quality. The number of pests that can be tolerated varies widely even for the same species in different areas on the same crop and at different stages of crop maturity. The presence of an insect is not necessarily an indication of economic threat to the crop. In fact, low numbers may be beneficial or necessary in maintaining the parasites, predators, or pathogens of the pest. In most situations, complete control or eradication of a pest is not necessary.

When damage to quality, yield, or longevity is threatened and other factors such as parasites, predators, weather, etc. will not prevent it, pesticides will be needed. This is often referred to as economic threshold or damage threshold. Economic threshold levels are not always available for a given crop, pest or locality. The decision to apply a pesticide or not is usually based on past experiences and knowledge of the costs or risks versus benefits to result from control. Costs of damage that will result without control must be weighed against the cost of control. In making this decision, one must consider the following questions:

1. Is the pest population approaching levels that may cause economic threshold damage?
2. Are natural controls (parasites, predators, weather, etc.) present and likely to reduce the population before economic loss results?
3. Will the costs of the pesticide and the labor needed to apply it be less than the gains to be made?
4. What effect will the pesticide have on the environment and the beneficial non-target animals?
5. Can the crop be harvested before damage is serious?

The dollar return from control should be greater than the cost of control. Example: Alfalfa can recover after sustaining substantial damage from the alfalfa weevil. Or, it can be harvested before serious damage results. But, a little patch of late blight in a field of potatoes or tomatoes is a warning of serious damage to follow. Any good commercial applicator should be able to advise his client and carry out the necessary control procedure. Example: The control procedure should result in production of a crop or preservation of a forest stand where otherwise this would be lost. Most often there is no easy way to estimate cost benefit ratios in dollars. But you should at least be able to identify specific benefits that will result from control of a pest, so these may be weighed aginst cost plus any possible adverse effects of the procedure.

When damage becomes noticeable, the best timing for control procedures is usually already past; you may have to accept the damage that year and wait until the next to apply effective control measures.

## Life Cycle

A thorough knowledge of the life cycle of the pest is important in making the decision as to whether or when to take control measures. Most, if not all, pests are most readily controlled at one particular stage in their development. The treatment for many pests must be applied before their damage is noticed. Example: most fungicides are protectants and must be on the plant or in the soil as a protective barrier before spores or mycelium of the pathogenic fungus contacts the plant. Most infection occurs under moist conditions. So, it is important to spray before rains come, not afterwards. Knowledge of the disease cycle is a key to proper application of preventative fungicides.

Preemergence sprays for weeds and preventative sprays for corn earworm based on egg observations, are other examples of the value of knowing life cycles. Once the earworm is in the ear it is difficult to kill and the damage is already done. Other pests may already be gone by the time their damage is noticed. Spraying is then a useless exercise and may harm beneficial forms. If you are not familiar with the life cycle or disease cycle and do not bother to look it up, you are not in a position to make the right judgements.

The proper control measure depends upon the biology of the insect, disease, or weed. If an insect is held partially in check by parasites, you may wish to use less pesticide for a slightly lower degree of control, so that the parasites will survive. For this reason, forest stands with low population of defoliating insect such as gypsy moth, and alfalfa fields with low populations of alfalfa weevil may be left untreated. In terms of disease, computerizing observations of temperature, rainfall, and relative humidity during the growing season has already led to an operational system for forecasting the occurrence of potato late blight. Fungicide sprays can be withheld or applied according to this forecast which is based on the biology of the disease. In one area this system saved the cooperating growers four sprays in one season. Knowledge of this disease cycle then, has led to financial saving, larger yields, reduction of crop injury by equipment, better blight control with less storage losses, and an appreciation of the professionalism of the commercial applicator. Since most fungicides must be applied before the plant is infected (protectants) rather than after the plant is diseased (eradicants), a complete knowledge of the particular disease is necessary for effective control.

An understanding of the growth habits of weeds is also a requirement for making judgements about chemically treating with herbicides versus cultivation, rotation, or other such practices. Part of the weed population in a given field can often be controlled by cultivation, but weeds within seedbeds or surrounding planting spots often must be controlled by application of an herbicide.

## Other Methods of Control

You should not fail to suggest supplemental cultural practices to your growers. One such practice is crop rotation. When a successful rotation program is followed, a pest specific to one crop will not carry over to the following crops. For example, potatoes should not be planted following sod if the white grub complex is present.

Sanitation practices such as cleaning up cull piles and plowing down old stubble are a definite help in eliminating overwintering or off-season sources of both insects and plant diseases.

The use of resistant varieties of food and feed crops can be practiced by everyone from the home gardener to the large agricultural producer. This concept has been followed for many years in the field of plant diseases. Now plant varieties resistant to insects are being produced, and experimental data is indicating varietal resistance of potatoes and tomatoes to weed competition. Most growers already tend to plant disease resistant varieties, since these are the ones commonly recommended and sold.

Such supplemental practices should not result in loss of business. There is plenty of work for competent commercial applicators; indeed many have problems meeting their obligations. But you can suggest ways in which your customers can aid in pest control, their businesses should be more efficient and profitable and your reputation and profits should grow with theirs.

# III. PESTICIDE APPLICATION EQUIPMENT

## Agriculture, Forestry, Ornamentals, Shade Trees and Turf

The equipment used in applying pesticides varies with the crop or other target, the type of application, the pest to be controlled and the formulation used. There are many different types, including granule spreaders, hydraulic sprayers, boom sprayers, airblast sprayers including mist blowers, soil fumigation machinery, and tarpaulin fumigation. They all have one requirement in common; they must apply the right amount of pesticide equally over the target area, and you must know at what rate they are applying. You know this as calibration.

Too little, uneven, or too much deposit are all inefficient use of material resulting in insufficient control, spotty control or excessive residue, respectively. Proper adjustment and calibration of the equipment can prevent needless waste of pesticide chemicals by depositing the required amount on the target.

The total deposit laid down on the target, excluding effects of drift or evaporation depends on:

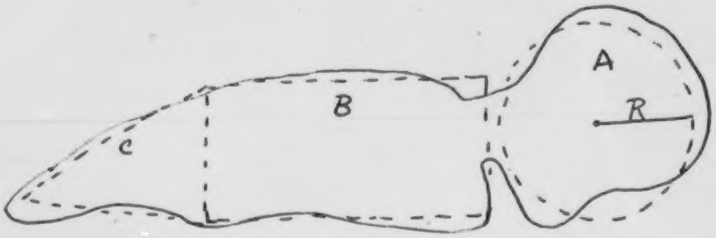
-- The concentration of pesticide in the tank. When spraying with a single nozzle or gun to the point of runoff, this is the important consideration.

-- The rate of discharge.

-- The speed at which the equipment travels.

-- The area covered (the swath width on turf, field or row crops, the distance between rows for fruit trees, the size of shade trees).

The total area (square feet) of rectangular or square areas to be treated can be determined by multiplying the width (W) by the length (L) of the area (W X L - area sq. ft.). Determining the area to be treated of irregular shaped areas such as golf greens is more difficult. One method is to determine the general shape of the area, then impose known shapes (circles, triangles, rectangles, and squares) over segments of the area where appropriate (see example below). The area in each shape is determined and added to the rest to obtain the total area to be treated.



Area A is a circle
Area = $3.14 \times R^2$
(R = 1/2 diameter)

Area B is a rectangle
Area = L X W

Area C is a triangle
Area = 1/2 X B X H (Base X Height)

Most of you already have your application equipment and are familiar with its performance. However, if you are buying new equipment, you will want to get some that is properly set up for the bulk of the work you intend to do. You have several sources of information available -- your extension service, other private or commercial applicators experienced in the same work and manufacturers. The manufacturer can usually furnish rather complete performance data and you should take full advantage of any charts, calibration aids or other help that he can supply.

## COMPONENTS OF PESTICIDE APPLICATION EQUIPMENT

Your core manual describes the principal types of pesticide application equipment. This section will describe some of the parts that make up application equipment of importance for use in agriculture, forestry, nursery, ornamentals, and turf. Determine your needs, then check manufacturers specifications to obtain the right equipment for the right job.

### Tanks

The tank is a major component of a sprayer. It should be large enough to avoid the need for too frequent refilling. (If your nozzle discharge is 10 gpm, a 100-gallon tank will last only 10 minutes. But, too large a tank is wasteful if it is seldom filled).

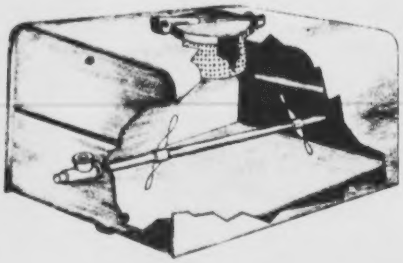
Stainless steel and fiberglass are considered the best tank materials because of their corrosion resistance, but they are expensive, so the buyer must weigh his need for durability against cost.

Every spray tank should have shut-off valves so that any liquid in the tank can be held there without leaking out of the pump, strainers, or other parts of the system which are serviced most frequently.

## Agitators

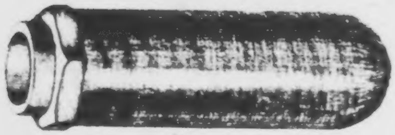
The need for agitation depends on the type of chemicals applied. Liquid concentrates, soluble powders, and emulsions (i.e., 2,4-D, malathion EC) require little agitation -- usually the flow from the by-pass hose is enough.

Wettable powder suspensions, however, require vigorous agitation to prevent settling out. Tanks with square corners require better agitation than tanks with rounded shapes.



There are two methods of agitating the spray material in the tank. Mechanical agitation, the most positive method, is provided by paddles or propeller. Hydraulic agitation is provided by the return flow of excess spray material from the pump. When hydraulic agitation is used to suspend wettable powders, a simple by-pass line from the relief valve is not enough. There should be a separate agitator line from the pressure side of the pump to the bottom of the tank.

## Strainers

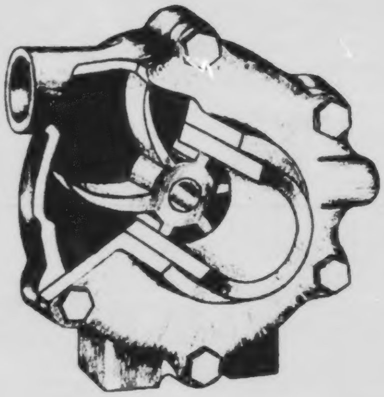


Strainers are used to prevent scale, rust flakes and other foreign material from plugging the nozzle or other working parts of your sprayer. They may be installed as necessary on the pressure line or may be purchased as a part of the nozzle and should also be placed on the intake line.

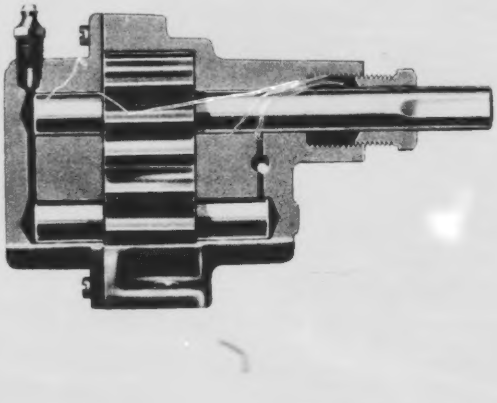
## Pumps

A good spray pump must deliver the required pressure and the required volume within its normal working capacity so it is not constantly working at its limit. If abrasive materials are used it must be able to pump them over a long period of time without much loss of performance. The metal parts must be resistant to corrosion if corrosive materials are to be used. You must choose gaskets, plunger cups and impellers that are resistant to swelling or chemical breakdown when using most liquid pesticides. If wettable powders are used the pump must be abrasion resistant.

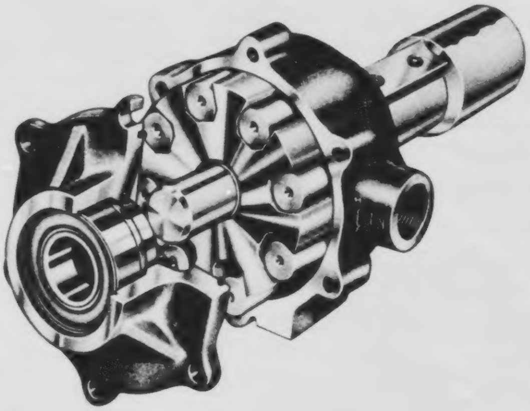
Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer. The pump will usually take this stress for a short time, but will soon break down or wear out. Never run pumps dry since they depend on the spray liquid for lubrication. Some spraying applications require only simple economical pumps. Generally speaking, as your pressure and volume requirements increase, the cost and complexity of a satisfactory pump also increases.



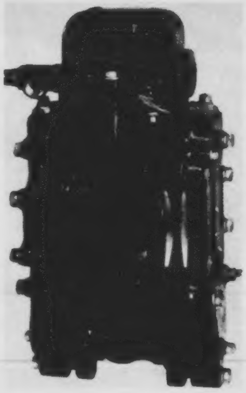
Centrifugal sprayer pumps use an impeller to give high volumes at low pressures, although two stage centrifugal pumps now used on some orchard and vegetable sprayers develop pressures in excess of 200 psi. The power requirement is relatively low and the operating speed is relatively high. They are the only sprayer pumps in general use that are not positive displacement pumps so pressure regulators or release valves are not essential. Pressure depends on RPM of the pumps. Because the impeller does not contact the pump housing, most centrifugal pumps are satisfactory for pumping abrasive mixtures such as wettable powder suspensions even when they are concentrated. Centrifugal pumps are not self priming so they must be mounted below the tank outlet or a priming system must be built in. They are relatively cheap, but are entirely satisfactory for many types of application.



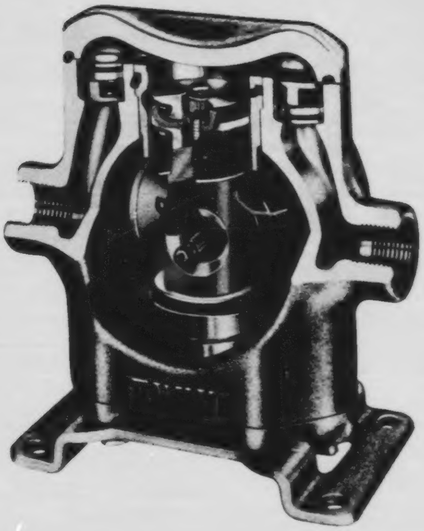
Gear pumps are simple, low priced positive displacement pumps that are used on agricultural sprayers for operating pressures of up to 100 pounds. They are satisfactory for pumping liquids or emulsions, but wear rapidly if suspensions are used. They are self priming when in good condition, but may lose that ability when worn. Depending on size, they deliver low to moderate volumes of liquid. They are not affected by solvents since all the parts are metal. Some are cast iron with stainless steel impellers; others are bronze so they will resist corrosion. They are commonly used on mist blowers and boom sprayers. Their power requirement is more than for centrifugal pumps, but is still relatively low. When a gear pump becomes worn it usually cannot be satisfactorily rebuilt.



Roller pumps are commonly used on low pressure and boom type sprayers. They are positive displacement self priming pumps with a slightly higher power requirement than gear pumps. They are also generally more costly but still relatively inexpensive. The rollers, made of nylon or rubber, are more abrasion resistant than the gears in gear pumps and can be replaced when worn or swollen. However, suspensions will wear the rest of the pump out after awhile. Roller pumps are capable of higher pressures than the gear pumps that are used on sprayers but sustained operation at maximum pressures will often cause the seals to blow out.

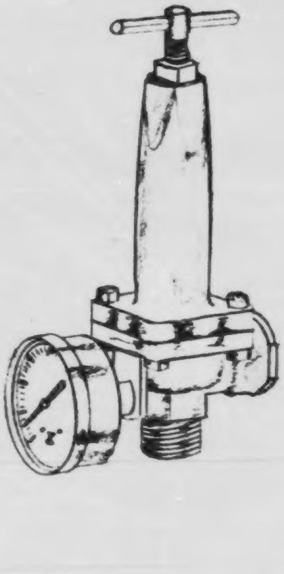


Diaphragm pumps are similar to gear and roller pumps in volume and pressure characteristics. Since the spray mixture does not come in contact with any moving metal parts except the valve assembly, these pumps are extremely abrasion resistant. The neoprene diaphragm may be injured by some solvents. Where volume or pressure requirements are not high these pumps are probably the best choice for abrasive spray suspensions.



Well made piston pumps are probably the most reliable of the commonly used sprayer pumps. They are heavily built and the larger ones are capable of pressures of 600 lbs/sq. in. or more. They deliver moderate to high volume depending on the pump capacity. The better quality pumps have replaceable plunger cups made of leather, neoprene or nylon fabric so they are abrasion resistant, easily rebuilt and capable of handling wettable powder suspensions year after year. The power requirement is higher than the other pumps. For low pressure sprayers a piston pump is not usually needed, but they are excellent where higher pressures are required or where both low and high pressures are needed.

## Pressure Regulators



A pressure regulator is one of the most important parts of a sprayer. The pressure regulator controls the pressure and therefore the quantity of spray material delivered by the nozzles. It protects pump seals, hoses, and other sprayer parts from damage due to excessive pressure and by-passes the excess spray material back to the tank.

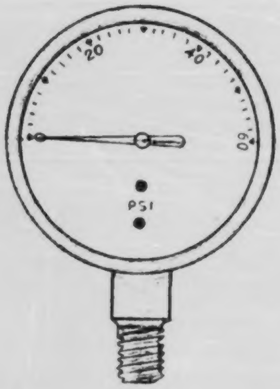
There are two types of pressure regulators, simple relief valves and pressure unloaders. The relief valves are simple by-pass valves that require the pump and engine to keep working just as though one were spraying, whereas the unloaders maintain working pressure on the discharge end of the system but move the overflow back into the tank at lower pressure, thus reducing strain on the engine and pump.

In the past almost all high pressure hydraulic sprayers were equipped with unloaders, but now, probably as an economy move, the trend is toward relief valves. There is no substitute for a spring-loaded pressure regulator.

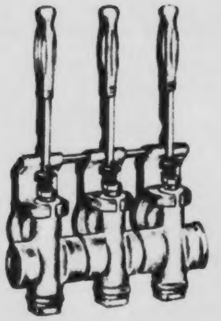
When selecting a pressure regulator, be certain that the flow capacity of the regulator matches that of the pump being used.

## Pressure Gauge

A pressure gauge is essential on any sprayer. Without one, the operator cannot tell how the sprayer is functioning. If the pressure does not remain constant, the amount of liquid coming out of the nozzles will vary. The gauge should always be mounted so that the operator can see it easily. Pressure gauges often wear out soon because they become clogged with solid particles of spray material. A glycerine loaded diaphragm type gauge is more expensive, but will last indefinitely.

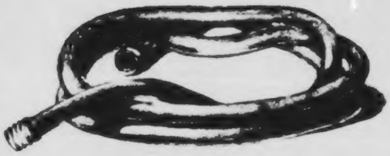


## Selector and Shut-Off Valves



The selector and shut-off valve allows the operator to conveniently select one to three sections of the boom for spraying a narrow strip in the field, or to shut off all sections of the boom quickly and easily at the end of the field.

## Hoses



There are four main points to consider in selecting sprayer hoses:

1) Composition (chief liner material)
2) Construction (reinforcement, rigidity or flexibility)
3) Working pressure
4) Size

High quality hoses and fittings are expensive but economical when used over a long period of time. The hose liner should be resistant to chemical action of the spray materials. The working pressure of the hose should be equal to the maximum pressure the pump delivers. If the hose is too small (inside diameter ) the sprayer will not operate properly. If the hose in the suction line is too small the pump will starve. If the hose in the pressure line is too small there will be excessive pressure and drop in volume.

## PESTICIDE EQUIPMENT

Depending on the crop being grown the following are examples of specific equipment for proper pest control. You will be responsible for knowledge of the equipment that is commonly used in your commercial category or subcategory.

### Agricultural

1) Plant

    Multipurpose sprayers

    -- Low and high pressure boom sprayers

        .. low - field and forage, vegetable

        .. high - vegetables, small fruit

    -- High pressure sprayers (hand gun and hose)

        .. Tree fruit, brush control, Christmas trees

    Airblast

        .. Tree fruit, small fruit, vineyard, vegetable, Christmas trees

    Granular

        .. Vegetables, small fruit, field crops, Christmas trees

    Soil fumigation

        .. Tree fruit, small fruit, vegetables

    Aerial

        .. Vegetables, tree fruit, small fruit, field and forage, vineyards, Christmas trees

### Forestry

Aerial
.. Forests
Mist blower
.. Forest nurseries, forest seed producing areas
High pressure (hydraulic) sprayer
.. Forest nurseries, forest seed producing areas

### Ornamentals and Turf

1) Arborist

    High pressure (hydraulic) sprayer
    Mist blower (airblast)
    Injectors

2) Landscapers
  - Multipurpose sprayers
  - -- High pressure sprayers (hand gun and hose)
    - .. Trees, shrubs, vines, turfgrass
    - .. Vines and turfgrass
  - Mist Blowers
    - .. Trees, shrubs, vines
  - Granulars
    - .. Trees, shrubs, turfgrass
  - Soil Fumigation
    - .. Turfgrass
  - Injector
    - .. Trees

3) Nurserymen
  - Multipurpose sprayers
  - -- High pressure sprayers (hand gun and hose)
    - .. Propagation house
    - .. Nursery blocks and fields
  - Mist blower
    - .. Propagation house
    - .. Nursery seedling beds
    - .. Nursery blocks and fields
  - Granular
    - .. Nursery seedling beds
    - .. Nursery blocks and field
  - Soil Fungicides
    - .. Nursery seedling bed
  - Aerial
    - .. Nursery field

4) Turf Managers
  - Multipurpose Sprayers
  - -- Low and high pressure boom sprayers
    - .. Low - golf course fairways, other turfgrass areas
    - .. High - golf course fairways, other turfgrass areas

-- High pressure sprayers (hand gun and hose)
  - .. Trees, shrubs, greens, lawns (school grounds, parks, industrial grounds, etc.)

Aerial
  - .. Golf course fairways, parks

Granular
  - .. Golf course fairways and greens, lawns (school grounds, parks, industrial grounds, etc.)

Soil Fumigation
  - .. Golf course greens

Multipurpose Sprayers

Agricultural (plant), Ornamentals and Turf, (Arborists,
Landscapers, Nurserymen and Turf Managers)

Multipurpose sprayers are designed to handle most spraying needs from low-pressure weed or row-crop spraying (30 to 50 pounds) up to higher pressure fruit tree and field-crop spraying (200 to 400 pounds or more).

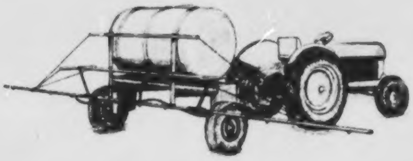
The sprayers have plunger- or piston-type pumps that deliver 3 to 8 gallons per minute at pressures up to 800 pounds. Tanks range in size from 50 to 800 gallons. The spray material is mechanically agitated.

Skid-mounted models are powered by an auxiliary engine. Wheel-mounted models may be powered by an auxiliary engine or by the tractor's power take-off.

Hand gun and hose are standard equipment; field booms, usually 20 to 35 feet in length, are available as optional equipment.

## Boom Sprayers-Low Pressure and High Pressure

### Agricultural (plant), Ornamentals and Turf (Turf Managers)



Sprayer booms are commercially available in lengths of 15 to 60 feet. The most common boom length is between 20 and 35 feet. Even with a 20-foot boom, it is essential to have some means of protecting the boom from damage if a tree or other obstacle is encountered. The most common boom is made in three sections -- one rigid section in the middle of the machine and a folding section extending out on each side. These outer sections are hinged at their inner ends and are supported from the center of the machine by a rope or light chain. This type of construction gives a 20- to 35-foot boom adequate support, and provides the versatility necessary in irregularly shaped areas and the mobility required when moving the sprayer through narrow gateways.

The height of the sprayer boom must be easily adjustable so the nozzles can deliver the chemical uniformly. Boom supports should be made so the boom can be set at any height from 12 to 48 inches above the surface being sprayed.

Your core manual describes low pressure field sprayers and high pressure (hydraulic) sprayers. While they differ somewhat in performance characteristics, both are used as agricultural and turf boom sprayers. The methods for calibration apply to both types of sprayer.

Boomless sprayers have a central nozzle or nozzles that are designed to produce a very wide spray pattern resulting in a wide swath similar to that laid down by a boom type sprayer. They may be calibrated by spraying a known acreage with water and refilling as described in your core manual.

There are four variables that you can adjust to govern the amount of spray delivered by boom sprayers. These are:

-- nozzle spacing on the boom

-- nozzle tip orifice size

-- pressure

-- ground speed of the sprayer

Usually your equipment will already be set up to meet your local needs, so you will make minor changes in spray delivery by changing the speed and/or pressure, and major changes by using larger or smaller nozzle tips. Routine checks of your sprayer should be made to make sure that the nozzles are not badly worn and have uniform output, uniform appearance of spray pattern and equal fan angle. Replace any nozzle tips having a flow of 10% more or less than required or having obviously different fan angles or patterns.

## Nozzle Bodies

A complete nozzle assembly consists of the body, screen, cap, and tip or orifice plate. The function of the nozzle body is to attach the screen and tip to the boom. Several different nozzle body designs are available. All designs perform adequately, but each design has advantages for specific spraying jobs.

## Nozzle Tips

A nozzle is an atomizing device that spreads the liquid droplets in a definite direction to form the spray pattern. Nozzles are made to accommodate a variety of replaceable tips or discs to meet different spraying requirements. Manufacturers of sprayer nozzles can supply data sheets for the delivery rate (usually in gal/min at different pressures for their nozzles). The application rate CANNOT be specified on these data sheets unless the forward speed of the sprayer and the spraying pressure are specified.

WARNING -- Never operate nozzles at high pressures to compensate for selecting the wrong nozzle size. Unnecessarily high pressures increase the rate of nozzle wear and increase the drift hazard.

Nozzle tips and discs are made of aluminum, brass, ceramic, plastic, stainless steel, or tungsten carbide. Tungsten carbide discs and stainless steel tips are more resistant to abrasive wettable powders, but they are more expensive than steel discs and brass tips. No single material is the least expensive, most corrosion resistant, and most durable for spraying all agricultural chemicals.

Nozzles are classified according to the spray pattern as (1) fan or flat pattern, (2) broadcast or boomless, (3) flooding fan, and (4) full cone or hollow cone.

The regular flat fan nozzle makes a narrow oval pattern with lighter edges. It is used for broadcast spraying. This pattern is designed to be used on a boom and to be overlapped 30-50 percent for even distribution.

**Flat Fan**—There are three types of flat fan nozzles:

Fan or Flat Pattern Nozzles

The spray droplets are arranged in a fan shape as they leave the nozzle. The orifice (opening) in this type of nozzle is elliptical. Herbicides are best applied with this type of nozzle because:

1) when a series of these nozzles is properly mounted on a boom, the spray material is more evenly distributed than it would be with any other type of nozzle; and

2) at 30 to 60 psi, the flat-pattern nozzle delivers small to medium droplets that do not drift excessively.

The most commonly used flat-pattern nozzles have a spray angle of 65, 73, or 80 degrees; the most commonly used pressure is 40 psi.

For most herbicide spraying done with a relatively short boom (20 to 35 feet), the 80-degree flat-pattern nozzle is best. It is possible to keep the boom relatively low to reduce the drift hazard, and give a uniform distribution of spray material over the entire length of the boom.

Special flat-pattern nozzles, usually called even-spray nozzles, are available for band spraying row crops. If a uniform distribution of herbicides is required, these nozzles should not be used.

The flat-pattern nozzle is available in brass, plastic, stainless steel, and hardened stainless steel. The brass nozzle is inexpensive and satisfactory for spraying chemicals in solution. It is not durable enough to spray any more than 20 acres with atrazine. The plastic nozzle is corrosion resistant but should not be used to spray more than 60 acres with atrazine. The stainless steel nozzle is corrosion resistant and durable but should not be used if more than 200 acres are sprayed with atrazine. The hardened stainless steel nozzle is the most durable, but it is not as corrosion resistant.

NOTE -- When using any wettable powders, it is essential to calibrate the sprayer frequently, because as a nozzle wears, the quantity of spray material delivered INCREASES.

### Broadcast or Boomless Nozzle

The broadcast nozzle is made of one or more nozzles in a cluster. These nozzles deliver a flat fan-like pattern that covers a swath up to 70 feet wide. The spray droplets range in size from very small to very large. Broadcast nozzles are convenient for spraying areas in which a uniform distribution of spray material is not essential.

**Broadcast**—This nozzle forms a wide flat fan pattern. It is used on boomless sprayers and to extend the effective swath width when attached to the end of a boom.

CAUTION: Never use a broadcast type of nozzle when there is any breeze. Severe drifting and crop damage may result.

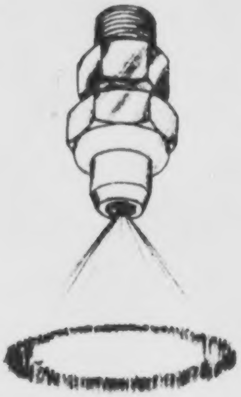
## Flooding fan

This is a broadcast-type nozzle that has been modified to be mounted on a boom. The nozzle spacing usually used is 40 to 80 inches. The small- to large-sized spray droplets are not distributed as uniformly as the droplets from a flat-pattern nozzle. The flooding-fan nozzle is available in brass or stainless steel. Its main use is for surface application of herbicides that are immediately incorporated into the soil.

**The flooding nozzle makes a wide-angle flat spray pattern. It works at lower pressures than the other flat fan nozzles. Its pattern is fairly uniform across its width. It is used for broadcast spraying.**

## Full Cone or Hollow Cone

These two types of nozzles deliver circular patterns. The hollow-cone nozzle delivers most of the material to the circumference of the circle; the full-cone nozzle delivers liquid droplets to the entire area of the circle. The circular opening in the stainless steel, hardened stainless steel, or tungsten carbide disc



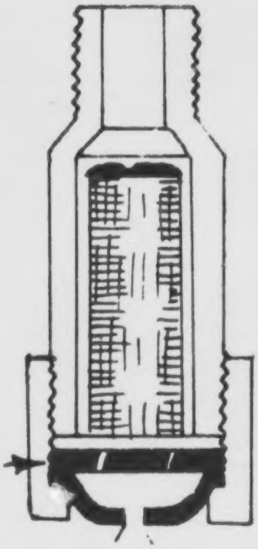
**Hollow Cone**—There are two types of hollow cone nozzles:

- the core and disk, and
- the whirl chamber.

The pattern is circular with tapered edges and little or no spray in the center. It is used for spraying foliage.

resists the abrasive action of wettable powders relatively well. The droplets are small or very small and not distributed uniformly when the nozzles are mounted on a boom. The major use of these nozzles is in the application of insecticides or fungicides to field crops where complete coverage of the leaf surfaces is extremely important and where spray drift is relatively unimportant. In cone nozzles the number of holes in the whirl plate affects the discharge rate. Be sure to check the whirl plate as well as the nozzle tips in calibrating a sprayer.

## Nozzle Screens



The screen is placed behind the nozzle tip and in the nozzle body to help eliminate, or at least reduce, the frequency with which the nozzle orifice becomes plugged. The size of the nozzle opening and/or the type of chemical being sprayed dictate the size and type of nozzle screen that should be used. For most general herbicide spraying, a 100-mesh monel or stainless steel nozzle screen can be used. When wettable powder suspensions are being applied, a 50-mesh monel or stainless steel nozzle screen should be used.

When the boom must be turned off frequently -- in small fields or when the crop may be damaged by an overdose of chemical -- nozzle "dribble" may be a serious problem. A nozzle screen with a check valve in it will help eliminate dribble and will not affect the operation of the sprayer. Some care must be taken to make certain that the ball bearing does not become glued to its seat or that dirt or chemical particles do not hold the ball bearing off its seat.

## Calibration of Boom Sprayers

There are several ways to calibrate boom type field sprayers. Your core manual gives you the method that is probably the simplest, but it also takes time because it requires spraying a measured acre with water. Another method involves timing the discharge rate of the sprayer over part of an acre and doing simple calculations. Neither of these methods cause variation in flow across the boom to be considered or corrected. Calibration jars that indicate rates of application over a given distance may be purchased.

## High Pressure Sprayers (Hydraulic), Hand Gun and Hose

Agricultural (Plant), Forestry, Ornamental and Turf (Arborist,
Landscapers, Nurserymen, and Turf Managers)

These machines are commonly used in turf, ornamental and shade tree spraying as well as for orchards and as boom sprayers for heavily foliaged vegetable crops. Usually they have piston pumps and mechanical agitators and are solidly built, long-lasting machines.

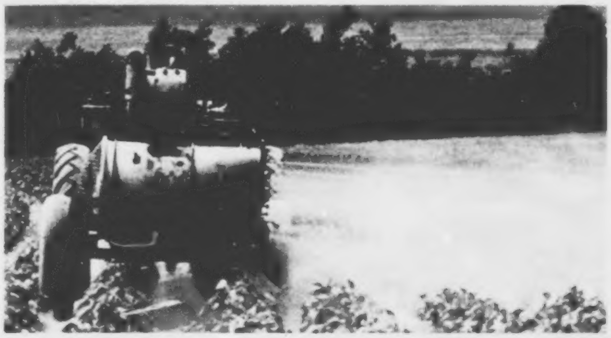
Usually high pressure hose and a hand-held spray gun are used when treating foundation plantings and other ornamentals, shade trees or nursery blocks, but a spray boom may be used when applying turf insecticides or fungicides.

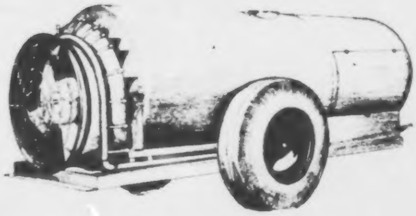
Foundation plantings, nurseries and turf can be treated with hydraulic sprayers of moderate pumping capacity such as 6 to 10 gpm at 400 - 500 psi.

Tall shade trees require high pressure, high volume pumps capable of 35 - 60 gpm at 650 psi. Spray mixtures used for ornamentals and shade trees are dilute, either suspensions or emulsions and the proper concentration of spray as mixed in the tank is applied to the point of runoff. Consequently, the sprayer does not have to be calibrated as long as it is big enough to adequately cover the target. When a boom is used for treating turf, the sprayer can be calibrated according to methods given in your core manual.

## Airblast Sprayers

### Agricultural (Plant)





Airblast sprayers are now in general use for treating tree fruits and are increasing in use for the spraying of row and field crops. (Mist blowers, a type of airblast sprayer, are used on shade trees and ornamentals.) They may be used to apply sprays ranging from dilute to highly concentrated. All use air to transport pesticides to the crop. Most use nozzles under pressure to provide initial breakup of the liquid, but some rely on airblast to shear the liquid into fine droplets. The volume and velocity of the airstream and the shape and arrangement of the air outlets vary depending on the purpose for which the machine was designed. It is essential that the airblast be sufficient to distribute the spray droplets throughout the swath to be covered.

Airblast machines for treating fruit trees are classified as follows:

1. Dilute spray (high gallonage) 301 or more gallons per acre.
2. Semi-concentrate (moderate gallonage) 101 to 300 gallons per acre.
3. Concentrate (low gallonage) 20 to 100 gallons per acre.
4. High concentrate (very low gallonage) 1 to 19 gallons per acre.

*5. Ultra high concentrate (ultra low volume) less than 1 gallon per acre.

---

*Not satisfactory for treating fruit crops at present.

Many machines may be modified to make applications in more than one classification. However, because of airblast and pump limitations, machines designed for low volume usually cannot be used for applying dilute sprays. Likewise, high volume machines are not efficient for use in applying low volume since the airblast and pump capacities would be excessive.

The principles for adjusting and calibrating airblast machines for treating fruit trees are the same regardless of the volume of water to be used.

Calibration Procedures (Trees)

1. Make sure that the fan and pump are operating at speed indicated in the operator's manual and that all strainers, nozzles and similar equipment are clean and in good condition.
2. Check the liquid pressure at the nozzle position on the discharge manifold. Pressures must be within limits set in your operator's manual and/or nozzle performance table.
3. Determine the effective airblast. Effective airblast is that part of the airblast actually used in covering the trees in question.
4. Make a diagram of the air outlet and liquid manifold. Indicate the effective airblast, nozzle positions and upper one-third of effective airblast.

5. Determine:

    a. Gallons per acre to be applied

    b. Distance between rows

    c. Speed at which the sprayer is to be operated

6. Use a calibration slide rule provided by the manufacturer or the formula given below to calculate gallons to be discharged from one side of the machine.

    Gal/min (per side) =

    $$\frac{\text{gals/acre X miles per hour (mph) X distance between rows (ft)}}{1000}$$

    For example, if one selects 200 gals/acre and 2 mph in an orchard with 25 ft. row spacing:

    $$10 \text{ gals/min} = \frac{200 \text{ X } 2 \text{ X } 25}{1000}$$

7. Divide gals/min per side by 3. In the case cited above this would mean 10 ÷ 3 = 3.33. Two-thirds of this volume or 6.7 gals. should be discharged through the upper 1/3 of the effective airblast and 1/3 of the volume or 3.3 gallons should be discharged through the lower two-thirds.

    Now consult a manufacturer's chart which matches the nozzles and nozzle pressure which you are using and select the appropriate sizes to give the desired rate of delivery for each position on the manifold. Spray coverage will be more satisfactory if nozzle sizes are selected which will give a gradual decrease in volume from the top to the bottom of the effective airblast, still maintaining the pattern of 2/3 of the liquid being discharged in the upper 1/3 of the airstream.

8. Install the desired nozzles in their appropriate positions. Unused nozzle positions above the effective airblast should be shut off but may be fitted with intermediate size nozzles for use during poor spraying conditions or for covering trees larger than those for which the sprayer was calibrated.

9. Fill the tank at least 1/4 full. Turn on the newly nozzled side and check the time it takes to empty the tank. Calculate the gallons discharged per minute. The example given in Step 6 indicated 10 gallons per minute as the desired delivery rate. At this rate the tank should empty in 5 minutes if 1/4 full is 50 gallons. Your allowable error should not be greater than 5% or 15 seconds. This means that a range from 4 minutes, 45 seconds to 5 minutes and 15 seconds is within desired limits. If the delivery rate falls within this range, nozzle up the other side and go to work. If not, go back over your calculations to find the error. If there is no error in your calculations the problem may be a faulty pressure gauge, wrong nozzle size, or obstructions that may have developed in strainers or other parts of the liquid system.

Most of the effort to calibrate and adjust a sprayer is lost unless it is operated at the right speed. Travel speed may be checked with a special speedometer, an engine tachometer (if proper adjustment is made for tire slippage) or by finding the number of trees you should pass per minute at the desired mph. Use the formula:

$$\text{trees passed/min} = \frac{\text{mph X } 88^{*}}{\text{tree spacing in feet}}$$

---

*1 mph - 88 feet per minute

If your trees are planted 25 feet apart and you plan to travel at 2 mph, then using the above formula you should spray 7 trees per minute.

$$7 \text{ trees/min} = \frac{2 \text{ X } 88}{25}$$

If you are spraying more than 7 you are traveling too fast; less than 7, too slow. Adjust your speed accordingly.

After the newly calibrated sprayer is operating satisfactorily periodic maintenance checks should be made to assure continued high performance. This should include checking the engine or PTO rpm, wear on the nozzles, strainers, pressure, and possible partial clogging of pipes and/or the hose lines and nozzles.

## Calibration (Row Crops)

Airblast sprayers for treating row and field crops should be calibrated using the same general procedure followed for those used to treat fruit trees. Slight variations in the procedure are as follows:

1. The swath width in row crop spraying is the distance between passes made across the field. The formula to calculate gallons to be discharged from one side of the machine then becomes:

$$\text{gals/min} = \frac{\text{gals/acre X mph X swath width in feet}}{500}$$

2. The most effective liquid discharge pattern within the airstream varies from one machine to another. In most cases it is necessary to discharge a large part of the liquid in the upper part of the airstream to assure proper deposits at the more distant parts of the swath. See manufacturer's operation manual for suggested nozzle sizes and arrangement.

3. You can check your speed by measuring the distance your sprayer travels in one minute and dividing by 88 (feet per minute traveled at one mph). Suppose you travel 176 feet in one minute:

$$2 \text{ mph} = 176 \div 88$$

## Mist Blowers

Forestry, Ornamental and Turf (Arborist, Landscapers, Nurserymen, Turf Managers

Mistblowers are airblast sprayers that are economical and effective for use against many pests of ornamentals and shade trees. They vary in size from small back pack blowers which are powered by 2 cycle engines that move a few hundred cubic feet of air per minute (cfm) at velocities up to 200 mph to large truck or trailer mounted machines that move up to 60,000 cfm at velocities near 100 mph. They may have single or multiple nozzles that inject the pesticide into a single air outlet. Usually the back pack models depend on the shearing effect of the airblast to break the pesticide into fine, mist-like droplets. Larger mist blowers may pump liquid under varying pressures through nozzles to initiate breakup, but these models also depend on the airblast for final breakup into fine droplets.

Since mistblowers are dependent on a column of air to carry the pesticide to the tops of tall shade trees they must be operated in little or no wind. Under good conditions there is no difficulty in reaching the tops of the tallest trees. However, operations should cease when the wind exceeds 4 - 5 mph. Otherwise, not only will it be difficult to reach tree tops, but excessive drift of pesticide will also result.

Emulsions are commonly used in mistblowers although wettable powders can be used. Some pesticides are available only as wettable powders or flowables. Usually relatively high concentrations of pesticides are used in mistblowers; a rule of thumb being 30 X dilute concentrations. One or two quarts of concentrate is often sufficient for a large tree. The insect pests best controlled by mistblowers are those that move to some degree, i.e., cankerworms and other worms and caterpillars, leaf beetles, lace bugs, etc. Pests such as mites, scales and fungi can be controlled but it is advisable to lower the concentration and increase the gallonage per tree accordingly.

Mistblowers are advantageous over hydraulic sprayers in that they are lighter in weight, use far less water and are physically easier to operate.

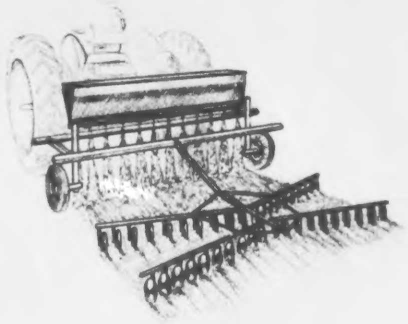
## Calibration

Mistblowers must be calibrated before using on ornamentals and shade trees. You do not apply pesticides in high concentration to the point of runoff as you do with hydraulic sprayers. In fact, it is difficult to see the usual mistblower deposit. Consequently, it is very easy to overdose. You must know the amount per minute of pesticide that your blower is delivering to the target and then time your application so that the right amount of spray concentrate is applied. Larger mistblowers are normally nozzled to deliver 1/2 to 2 gallons per minute (gpm). Thus, if a tree requires 2 quarts of 3% carbaryl spray and your blower delivers one gpm, you should treat the tree in 30 seconds. Your core manual tells you how to determine pumping rate, or as it is more properly called, delivery rate.

Sometimes it is necessary to apply a specified amount of pesticide per acre witha mistblower, for instance in treating nursery blocks or golf course fairways and greens. You can use the same procedure for calibration as is described for row crop calibration of airblast equipment.

## Granular Application

### Agricultural (Plant), Ornamentals and Turf
### (Landscapers, Nurserymen, Turf Managers)



Granular pesticides must be applied with precision. Application of less than 90% of the label rate may result in ineffective control. Applications greater than recommended are costly and may be injurious to the crop. To meet these rigid requirements, spreaders must be carefully calibrated.

The amount of granules applied depends on the size of the metering opening, speed of travel, roughness of the field, and the flow rate of the granules. Granules flow at different rates, depending on size, density, and type of granule, temperature and humidity. Therefore, it is necessary to recalibrate your applicator for each different formulation.

## Broadcast Applicators

These applicators may be of the full width hopper type with sliding gate openings or augers, or those using air, or spinning disks to cover swaths much wider than the machines.

With the full width sliding gate and auger types one should check the evenness of distribution from all the openings by setting the gate at a particular opening, turning the drive mechanism and comparing the output over a given time from each opening. Use the actual pesticide to be applied and a preliminary setting as recommended by the equipment operator's manual for the pounds per acre desired.

For the air and spinning disk types, select a preliminary setting as recommended by the operator's manual for the application rate desired. Select and determine your actual travel speed, then check the distribution pattern in the field. Containers deep enough to keep the granules from bouncing out should be placed on two foot centers across the swath at several intervals along the first pass. Then visually, volumetrically, or by weight compare the output at each station. This will alert you to any correction needed and allow you to select the best swath width.

To check the application rate, fill the hopper, settle the material in the hopper, then refill. Treat a known acreage using at least 10% of hopper contents and determine the pounds of granules required to refill. Then:

$$\text{pounds per acre} = \frac{\text{amount used (in pounds)}}{\text{acres covered}}$$

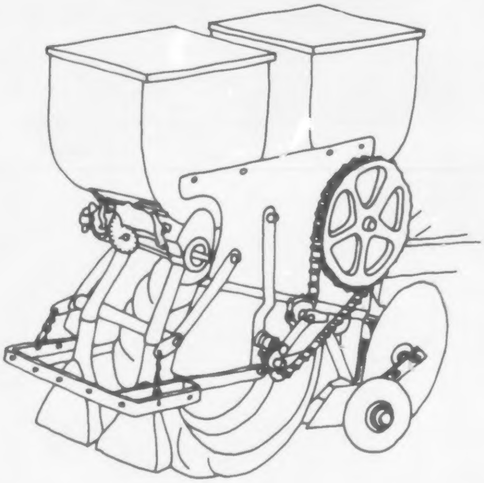
If the pounds per acre used is within 10% of that desired, treat another acreage and recheck the delivery rate, then make minor adjustments to correct the rate to within 5% and keep the delivery rate frequently rechecked during application.

If the amount used is more than 10% in error, then change the applicator's rate settings and recalibrate. Keep calibrating until the rate is correct to within 5%.

Remember most units require that speed be held almost constant to keep the application rate constant. Also weather conditions can markedly affect granular flow rates so be alert to such changes.

## Band or Row Applicators

These applicators should have tubes to the spreader which are not too long nor too shallow. Some use a flexible metal hose to carry granules from the hopper to the ground. The hose must not be too long for even flow or the application rate will vary along



the row. Careful adjustment of the hose position or length may be necessary to provide uniform flow.

Banders should spread the band evenly even when on 10 to 15% slopes. Chain drives should use sprockets of 8 teeth or more to keep the drive speed uniform. Design should be such that the flow of granules stops when the drive stops even when the outlets remain open. The drive should be strong enough to turn and not break when restarted after road travel even when the hopper is full of granules.

Care must be taken to insure the placement of the granules over the row or in the row as the pesticide label directs. Proper placement in some cases is as important as proper calibration.

Band applicators should be calibrated in the field just like broadcast granular applicators, after first calibrating in a manner similar to row or directed sprayers (outlined below).

Step 1. Set each individual applicator to apply the desired amount per acre as suggested in the equipment operator's manual.

Step 2. Fill hoppers at least half full, turn on applicators and run until all begin feeding.

Step 3. Disconnect nozzle of spreader and attach container under each tube.

Step 4. Travel a measured distance (at least 1/8 mile or 660 feet) at the speed you wish to apply in the field.

Step 5. Weigh the amount recovered for each band separately and record. Use an accurate scale such as a postal or kitchen scale.

Step 6. Calculate the application rate for each unit using Equations 1 and 2 where the band width (in feet) is the swath width.

Equation 1:

$$\text{acres covered} = \frac{\text{Distance traveled (ft) X swath width (ft)}}{\text{43560 (sq. ft/acre)}}$$

Equation 2:

$$\text{application rate (lbs acre)} = \frac{\text{amount used (lbs)}}{\text{acres covered}}$$

-- This is the broadcast rate per acre and the rate the pest is subjected to in the banded area. The amount used per crop acre will be reduced by the ratio of band width to distance between rows.

-- For some pesticides such as soil insecticides the recommended rate is in lbs. per crop acre in which case use row spacing (in feet) for swath width in Equation 1 and your answer will be in lbs. per crop acre directly.

-- If the recommendation is in lbs. per 1000 ft. of row, then:

$$\text{lbs/1000 ft. of row} = \frac{\text{lbs. collected X 1000 ft.}}{\text{distance traveled (ft.)}}$$

Step 7. If the delivery rate isn't within 5% of that recommended on any unit, adjust it accordingly and repeat Steps 3 - 6 until it falls within the 5%.

Step 8. Use the method described for broadcast application during the first part of each application to check the delivery rate. Adjust the settings accordingly.

## Soil Fumigation Application

### Agricultural (Plant), Ornamental and Turf
(Landscapers, Nurserymen, Turf Managers)

Equipment used for applying liquids or fumigants to the soil varies considerably, but all use one of two basic methods of metering out the liquid fumigant. The method of metering does not affect the efficiency of the material. Preferences of metering equipment are usually based on cost, simplicity, accuracy, practicality and the specific needs of the applicator. The two methods of metering are:

1. Orifice (opening) size is selected to restrict flow from a system which maintains constant pressure at the orifice. Constant speed is necessary to maintain uniform application rates. Pressure regulation varies with the equipment but is usually one of three types.

   a. Constant head gravity flow. These units utilize a closed drum or tank with a special breather to establish a constant head of about 1/2 to 1/4 psi, dependent upon height differences between breather inlets to tank and the vented orifice. Needle valves, orifice plates and capillary coils are used to control flow rate. Capillary coils can vary in both length and diameter, but for any one application must be all the same length and diameter for equal pressure and delivery at the outlet.

   b. Pump and pressure regulator. Gear, roller, diaphragm or similar pump units utilize either a power take-off or other power source. They generally operate at low to moderate pressures (5 - 20 psi).

   c. Gas pressure. This method generally is used with highly volatile fumigants such as methyl bromide. Pressure approved storage tanks and pressurized nitrogen cylinders are used and a constant pressure in the fumigant tank is maintained with one of a variety of pressure regulation devices operating at 5 to 35 psi depending on the fumigant and metering system used.

2. Metering pumps are driven from a ground wheel and are geared to the pump. Full output of the pump or pumps is forced out of the orifices. Changes in output are adjusted by changing the gear ratios and/or the length of the pump stroke. Uniform output is independent of tractor speed. Piston pumps are most common but gear, roller, diaphragm or similar pumps can be used.

Some of the principal methods used for soil treatment are:

1. Injection systems. These are used for fumigants but can be used for other liquid soil pesticides.

   a. Chisel cultivators, blades, or shanks with volatile materials may be 8 inches or more apart; with non-volatile materials, banding or 1 to 2 inch spacing between chisels is necessary.

   b. Sweep-type cultivator shovels.

   c. Planter shoe.

d. Plow.

e. Transplant water.

2. Surface treatment/soil incorporation. This method is used mostly for low or non-volatile materials. Mixing is usually shallow, 5 inches or less. The simplest method is to spray soil, turn it in with disks and compact with a drag, float or cultipacker. Rotary hoes or weeders are also used. Non-volatiles are sometimes applied as granules.

3. Drenching and flooding. These methods are usually used prior to planting, but material may also be applied by irrigation water.

## Calibration

This equipment can all be calibrated in the same manner as boom broadcast and band sprayers (See Core Manual). However, fumigant labels usually specify the desired flow rate as fluid ounces per 100 or 1000 feet of travel, or as feet traveled per pint of fumigant. A simpler technique is described below:

1. Establish the speed to be used in application by setting equipment at depth to be used, and then, leaving fumigant valves turned off, drive across a tilled field at a rate that allows a constant travel speed. This speed is determined in feet per minute and converted to feet per second by dividing by 60. If the tractor has a speedometer, its speed per second can be calculated by multiplying miles per hour by 1.45.

2. Determine collecting time:

   $$\text{collecting time (seconds)} = \frac{\text{distance suggested on label}}{\text{speed in feet/second}}$$

   For example, if the label lists "X" ounces to apply per 1000 ft and speed is 8 ft/second, then:

   $$\frac{1000}{8} = 125 \text{ seconds necessary to apply "X" ounces}$$

3. With the orifice pressurized and constant speed units, keep the unit stationary and with pump or pressure system operating at some preliminary setting:

   a. Collect the output for the collection time calculated above (Step 2).

   b. If the amount is more than 5% above or below the ounces per 100 or 1000 ft recommended on the label, change the pressure or orifices until the right amount is collected.

There are tables available that approximate the output for each fumigant over a range of pressures and orifice sizes.

4. With ground-wheel driven metering pump units:

   a. Determine the circumference in feet of the tire on the ground driven wheel.

   b. Divide the calibration distance by the circumference to obtain the number of turns needed for that distance.

   c. Turn the wheel the calculated number of turns while collecting the output from one or more of the outlets. If the amount is not right, change the gears or sprockets in the drive or change the length of the piston stroke and then recheck the delivery until it is within 5% of the amount recommended on the label.

5. Once field application is started, check the application rate immediately and often thereafter by comparing the amount used and the acreage covered.

   NOTE: Row treatment rates and calibration can be kept less confusing by remembering that flow rates per outlet are usually the same as for broadcast fumigation.

Tarpaulin Fumigation

When odorized methyl bromide (98% methyl bromide, 2% chloropicrin) is used, the area to be treated is generally covered with polyethylene sheeting (tarp). The tarp should be supported off the ground (not flat on the ground) to permit free movement of the gas under the tarp. The tarp should be sealed by laying the edges of the tarp in a small trench or furrow and covering 6 - 10 inches with soil. Care should be taken not to move any of this untreated soil onto the treated area when removing the tarp.

The fumigant can be introduced into evaporation trays using 1 pound for each 100 square feet of area to be treated, and adding the recommended amount of fumigant to each tray. Methyl bromide with 2% chloropicrin added as a warning agent (odorized) is available in small metal pressure cans (1 or 1-1/2 pounds). Also available are applicators with openers each with polyethylene tubing attached to introduce the liquid into the evaporation trays under the tarp. For larger jobs, large cylinders may be used with application tubing attached and utilized in a similar manner to that above. The amount of odorized methyl bromide applied can be measured by placing the cylinder on a scale and measuring loss of weight, or using a special cylinder-metering device attached to the cylinder. In either case, the amount required per evaporating tray is metered out and generally introduced into numerous evaporation trays.

Tarped fumigants can also be injected by tractor-drawn chisel applicators. Commercially, overall tarping is the most efficient and common practice. A tarp layer is mounted behind the chisel applicator. In laying the tarp, one edge of the tarp is buried with bedding disks and the other edge glued to the adjacent laid strip of tarp, with the first strip having both edges buried. Fumigant injection and tarp laying proceeds until the entire field is covered with overlapping strips of polyethylene tarp.

Another less efficient and more time-consuming method is to treat alternate strips of equal width, burying both edges of the tarp. After 1 - 2 days' exposure, the tarps are removed by splitting down the middle, removing each half toward corresponding edge to assure moving the untreated soil, burying the tarp edges into the untreated area for treatment. Injection and tarping are then repeated covering the untreated strips. A third system uses heavier tarps that combine manual, mechanical, and stripping methods of injecting, tarping and covering, allowing multiple spaces between strips. After 1 - 2 days' exposure, the buried far side and ends of the tarp are uncovered, the next strip is injected, the tarp is flipped, and the edges sealed. The process is repeated every 1 - 2 days until each area between the original strips has been treated.

## Aerial Application

### Agricultural (Plant), Forestry, Ornamental and Turf, (Nurserymen, Turf Managers)

The key to successful aerial application of pesticides is obtaining uniformity of the initial spray deposit over the plant canopy. The chemical will then be redistributed by dew, rain, or overhead irrigation to other parts of the plant including lower leaf surfaces, stems and fruit. The key to uniform aerial application is the design and adjustment of the spray distribution system and the operation of the aircraft.

The advantages of aerial application are summarized below. The most important is the speed of coverage in order to combat widespread and fast developing epidemics when they strike major large acreage crops such as corn, cereal grain, potatoes, and vegetables. One aircraft can do more work in an hour than most ground rigs can do in a day. Aircraft can spray fields that are too wet for ground equipment, which is often the case when fungus pests are most active. Aerial application must be done by a certified aerial applicator.

## Advantages of Aerial Application

1. Faster, better timing.
2. Can be used on wet fields following rain or irrigation.
3. Eliminates wheel damage and soil compaction caused by ground equipment.
4. Reduces mechanical spread of virus and bacterial disease.

5. Uses less water.
6. No runoff.
7. Lowers the grower's capital investment.
8. Reduces labor requirements.

Disadvantages of Aerial Application

1. Some fields inaccessible or too uneven or too small for successful flights.
2. Inherent potential for environmental pollution and drift damage.
3. Certain crops and certain pest problems not suited to aerial application.

Injection and Implantation

Ornamental and Turf (Arborist, Landscapers)

The application of insecticides, fungicides and nutrient elements directly into shade and ornamental trees by injection and implantation are relatively new aspects of practical tree care.

Injection

Solutions are fed by gravity or pressure into holes (drilled or punched) in the trunks or root buttresses just above soil line. Ordinarily, injections are made every few inches around the trunk of a tree in order to insure distribution of the chemical into all the major branches. Pressure is usually provided by compressed air, as from the tank of a hand-operated compressed-air sprayer. Pressures of 10 to 40 psi are effective. Best uptake of solutions occurs on warm sunny days when trees are in leaf. Most movement of injected chemicals is upward; injections are not used for pests and diseases of roots. Suspensions containing insoluble particles are not satisfactory for injection because the particles tend to clog the water-conducting vessels of the wood.

Depth of injection is important. Holes that extend deep into the wood are not desirable. The most effective transport of the pesticide occurs in the outermost sapwood. That is where the injector should deliver the chemical. Injection into deeper lying wood results in failure of much of the injected chemical to reach the target -- wood of the current season, bark, or leaves.

Diameter of the injection hole is also important. The smaller the better. Small holes heal quickly.

Because healing processes in trees occur in both the wood and the bark after a tree is wounded for injection, an injection site can be used only once. Within several days after a hole is drilled into healthy sapwood, the tree reacts by isolating the wound from healthy tissues. This occurs before visible evidence of healing. Liquids can neither move into or out of a tree through such a wound.

## Advantages of Injection

All or nearly all of the pesticide is placed within the tree where it is more or less rapidly distributed upward to the fine branches and leaves. There is little waste, and hazard of environmental contamination is minimal. Heavy, expensive equipment is not required.

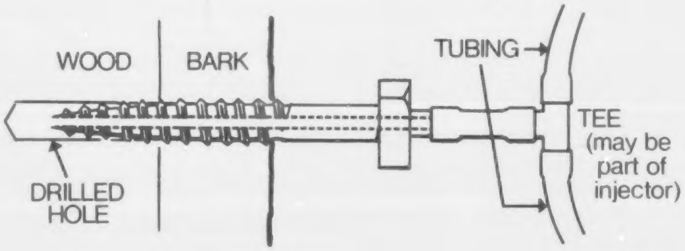
## Disadvantages of Injection

Internal distribution of injected chemicals is not uniform. Some branches may receive more chemical than is needed, while others get little or none. For some pesticides applied by injection, the margin between effective dose and phytotoxic dose is small. The proper total dose depends upon tree size and must be determined for each tree to be treated. Bleeding of sap or resin from injection sites sometimes occurs, especially in spring, or if holes have been drilled deep into the wood.

## Types of Injectors

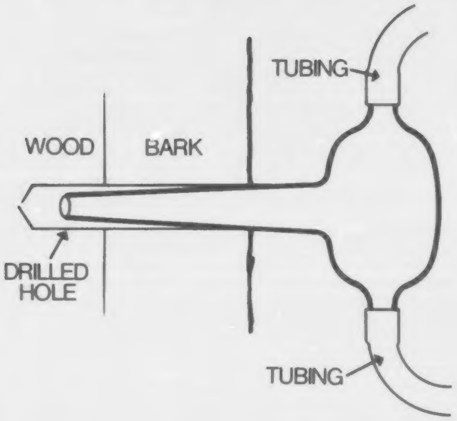
There are as many types of injectors as there are innovating people interested in tree injection. Three general types are shown.

1. Threaded pipe tee or lag bolt with drilled center and split tip, turned into drilled hole. A quick-connect or finger-tight fitting

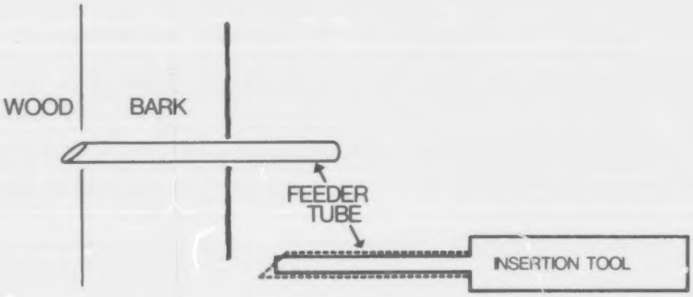


brazed on the bolt head allows connection to feeder line and reservoir.

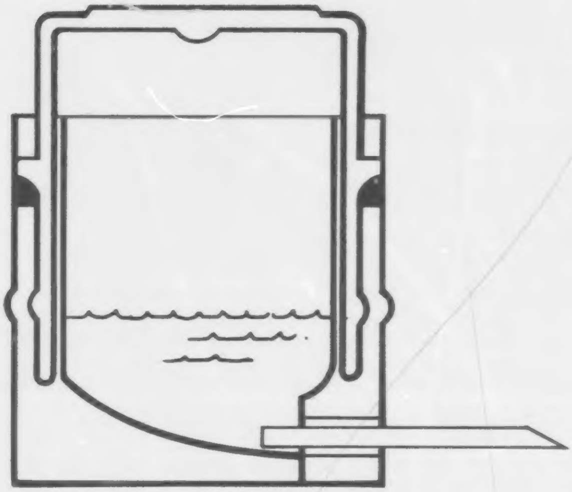
2. Tapered plastic or wood spile, tapped into drilled hole, held in place by friction, connected by finger-tight fittings or plastic connectors to feeder lines.



3. Aluminum feeder tube, driven into trunk using a special insertion tool. Insertion tool has a solid steel shaft on which the feeder tube fits as a sleeve while being driven through the bark. Blunt end of shaft penetrates easily only to the wood, thus positioning the tip of the tube in the outermost sapwood. Feeder tube is then connected to



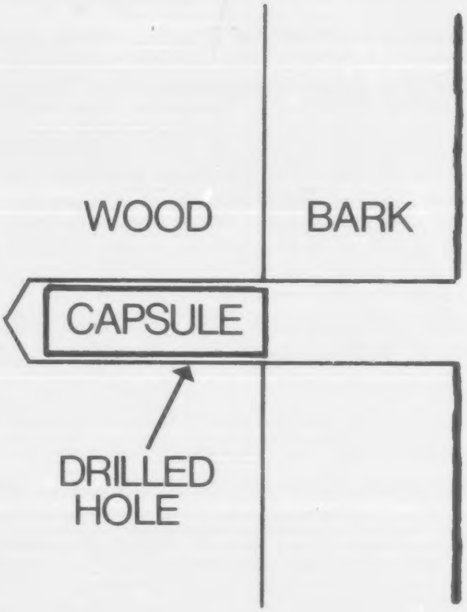
delivery tubing or, usually, to capsules that act as separate reservoirs. Contents may be pressurized slightly, after connection to feeder tube, by squeezing together the two halves of the capsule.



Implantation

Solid chemicals, usually in water-soluble capsules (or plastic capsules with soluble membranes over perforations) are inserted into holes drilled into the outer sapwood. Sap from the living wood dissolves the capsule or membrane and the chemical. This allows the chemical to be carried upward in the sap stream.

Capsules are inserted so that the outer end is flush with the surface of the wood, and are not removed.



In comparison to injection, implantation has the advantage that a tree need be visited only once for application of the pesticide, and no specialized equipment is necessary. The main disadvantage is that the technique can be used only for applying small amounts of chemicals.

## OPERATING PRECAUTIONS FOR PESTICIDE EQUIPMENT

1. Never use a pin, knife, or other metal object to unplug a nozzle. Use compressed air, an old toothbrush, or a brush with soft bristles. Never blow into a nozzle to clean it.
2. Never allow dirty water or debris to enter the tank.
3. Control spray drift by:
    a. Using the largest nozzles and the lowest pressure that will apply the pesticide properly.
    b. Keeping the boom as low as permissible.
    c. Spraying on days without wind or breeze.
4. Do not use corrosive fertilizer solutions in an ordinary weed sprayer. Parts made of brass, copper, steel, aluminum, or even galvanized materials may be severely damaged, unless the sprayer is cleaned carefully.
5. Never operate a sprayer with any of the screens or filters removed. If the screen constantly becomes plugged, replace it with a screen of the proper mesh and capacity.
6. Never fasten a power take-off driven pump solidly to the tractor. The chain provided will keep most sprayer pumps from rotating. Fastening the pump with a bar usually causes rapid bearing wear.
7. Never allow any sprayer pump to run without water, even for a short time; pump seals, bearings, and other working parts may be severely damaged.
8. Always pump a large amount of clean water through the sprayer at the end of the day or when changing from one pesticide to another. Clean all nozzle tips and screens at the same time. This helps reduce the gummy deposits or the accumulations of wettable powders in the sprayer.
9. Airblast or mist sprayers are designed to apply insecticides and/or fungicides. They should never be used to apply herbicides, especially hormone-type herbicides such as 2,4-D.

## CLEANING THE SPRAYER

There is no satisfactory way to completely remove all traces of any herbicide from a sprayer. Traces of chemicals in solution (2,4-D, for example) cannot be completely removed from porous tanks, or from hoses, pressure regulators, selector valves, or screens. If a herbicide sprayer must be used to apply an insecticide or fungicide, do not apply the insecticide or fungicide to a crop that may be damaged by the herbicide. Chemicals in suspension (such as atrazine) may not be as difficult to remove from the sprayer, but traces may still be present unless all parts are thoroughly cleaned.

## END OF THE DAY CLEANING

At the end of the day or whenever wind or weather conditions force you to stop spraying, clean the sprayer to prevent gum or powder deposits in the pressure regulator, selector valve, nozzle tips, and screens.

Follow these steps:

1. Rinse the inside and outside of the tank three times with clean water.
2. Put in a moderate amount of clean water and spray it out. A small amount of liquid detergent added to the water will help clean the inside of the sprayer system.
3. Clean the nozzles, nozzle screens, and suction screens with compressed air or a soft brush. Replace the screens and nozzles.

CAUTION -- Never clean a sprayer near susceptible plants or where the wash water could contaminate farm ponds, streams, or other supplies of water.

## STORING THE SPRAYER

When you store your sprayer properly, you add years to its useful life.

1. Clean the sprayer thoroughly.
2. Completely lubricate all moving parts according to the manufacturer's recommendations.
3. Make a list of all faulty parts and order the new ones to be ready for the following spring.

4. Fill the tank with water and add the recommended quantity and type of rust inhibitor or new light oil (see your instruction manual). Drain the tank. Leave all tank openings uncovered for ventilation, but screen them to keep out dust debris, insects and animals.

5. Clean all nozzle tips and screens with compressed air or a soft brush and kerosene. Store the tips and screens in a jar of new light oil or kerosene.

6. Take the weight off of any tires.

7. Remove, clean and drain the pump. Fill it with the light oil, anti-freeze or rust inhibitor recommended by the pump manufacturer. Seal all pump openings to keep out dust, dirt, insects and animals.

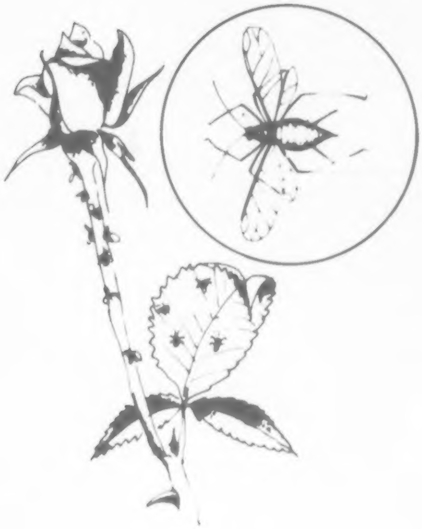
NOTE -- Make certain that no water is left in the pressure regulator, selector valve, or the boom. These parts will be severely damaged if water freezes in them.

## SOME COMMON SPRAYER TROUBLES

| Problem | Cause | Remedy |
|---|---|---|
| Loss of Pressure | 1. Pressure regulator improperly adjusted or stuck open. | 1. Adjust pressure regulator. |
| | 2. Suction screen plugged. | 2. Clean screen thoroughly. |
| | 3. Suction hose cracked or porous. | 3. Replace hose. |
| | 4. Pump worn. | 4. Replace or recondition pump according to manufacturer's instructions. |
| | 5. Nozzle tips or orifices worn. | 5. Replace nozzle tips or orifices. |
| | 6. Gauge faulty. | 6. Replace gauge. |
| Excessive Pressure | 1. Pressure regulator improperly adjusted or stuck closed. | 1. Adjust pressure regulator. |
| | 2. By-pass hose plugged or too small. | 2. Unplug the hose or replace it with a larger one. |
| | 3. Gauge faulty. | 3. Replace gauge. |
| Pressure gauge needle jumps excessively | 1. Gauge too sensitive. | 1. Replace gauge or mount a flow restrictor or needle valve. |
| | 2. Air cushion for the surges in liquid flow is gone (surge tank is water-logged). | 2. Admit air into the pump's air chamber, or install an air chamber on the pressure side of the pump. |
| Plugged nozzles | 1. Nozzle screen too coarse. | 1. Replace with the proper mesh screen. |
| | 2. Water, chemical, or tank not clean. | 2. Drain tank and clean thoroughly; check suction screen for holes. |
| | 3. Nozzles too small. | 3. Replace with the proper nozzles for the chemical being used. |
| | 4. Boom plugged. | 4. Remove the plugs in the ends of the boom section to clean the boom. |

## APHIDS

### DESCRIPTION



Aphids or plant lice are small, soft-bodied, slow moving insects which feed by sucking juice from plants. They can usually be recognized by the pear-shaped body and fairly long antennae. Aphids vary in color -- white, gray, green, brown, yellow or black. They are usually found in large numbers (colonies) on the undersides of leaves or on stems. There are both winged and wingless aphids in most species. As the aphids feed, they secrete honeydew -- a sticky, shiny substance seen on leaves, which consists mainly of excess sap ingested by the insect and passed through the body.

### LIFE CYCLE

Most species of aphids overwinter in the egg stage. The eggs hatch in the spring to produce a generation of females. These female aphids give birth to living young. Generally, the first young aphids are wingless, however when a colony becomes too crowded, winged forms may be produced. The winged forms migrate to new host plants and begin new colonies. Enormous populations are built up from this overlapping of generations all summer long.

Late in the season the aphids migrate back to the original host plant, and a generation consisting of both males and females is produced. These individuals mate and the females lay eggs that overwinter.

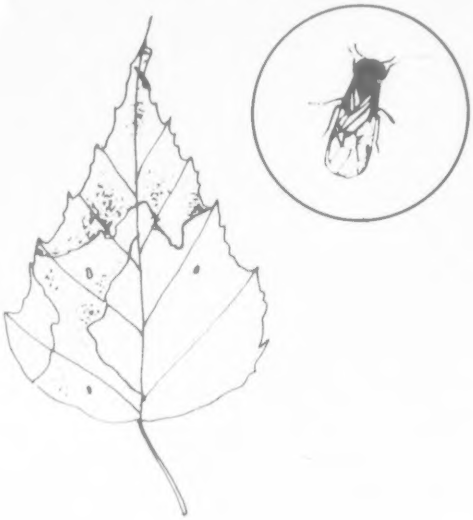
### DAMAGE

Aphids may damage many plants including fruits, vegetables, and ornamental trees and shrubs. The major damage is caused by the aphids sucking the juices from the stems and leaves causing a reduction of vigor, curling and distortion, and reduction in yield. Some species inject saliva into the plant tissue as they feed and may transmit virus diseases from one plant to another.

In addition to the direct damage caused to the plant by the feeding aphid, a black fungus, known as sooty mold grows on the honeydew secreted by the aphid. Sooty mold is unsightly and in association with honeydew is objectionable to the buyer of affected fruits or vegetables.

## BIRCH LEAF MINER

### DESCRIPTION



The adult birch leaf miner is a small, black sawfly. It is about 1/8-inch long, with a wingspread of about 1/4 inch. The larvae are small, whitish, and slightly flattened in appearance and when fully grown are nearly 1/4 inch in length. The larvae and black fecal matter are easily seen in the mines when infested leaves are held up to the light. Young larvae have four characteristic black marks on the underside of the body. These marks disappear when full growth is attained.

### LIFE CYCLE

In the spring, during mid-May, the adult sawflies emerge from the soil and fly to the birch trees. The adults are very short lived and are rarely seen except during periods of egg laying at which time they fly and crawl over the leaf surfaces. Females begin egg laying as soon as the leaves unfold from the bud. The eggs are inserted singly inside the soft, newly expanding leaves. After a week or ten days the eggs hatch and the tiny larvae begin to feed on the tissue between the upper and lower leaf surfaces. As the larvae feed, the individual blotches or blisters become larger. The mines are often united to form a single large area in which the larvae then live together. After a period of one to two weeks the larvae are mature and have finished feeding. They chew through the leaves and drop to the ground. There they work their way into the soil, pupate, and later emerge as adult sawflies. A generation is completed in five or six weeks. Since the life cycle from egg to adult is short, there may be two, three, or more generations each year, depending upon location and favorable weather conditions. The second and succeeding generations concentrate on the tops of trees, on terminal or new leaves, and on sprout growth where the leaves are tender. The last generation of larvae at the end of the season remain in hibernation in a cell in the soil until the following spring.

## DAMAGE

The partially or completely discolored and translucent leaves on birches are signs of damage by the birch leaf miner. The mining or tunneling of the leaf tissues by the larvae produces conspicuous blotches or blisters on the leaves which later turn brown. Some birches are almost completely browned from top to bottom due to the feeding activity of the insect. However, the tops of the trees are often the most seriously affected portions.

The first generation of the insect, which can have up to four generations in a season, depending upon the locality and climatic conditions, causes the most damage. Adults begin egg laying in the spring at the time the leaves start to unfold. At this time of the year all leaf tissue is soft and favorable for larval development. Some damage may be done by the second generation, while infestation by succeeding generations during the same season is of little importance. The second and succeeding generations also may attack sprout growth, where foliage is soft and new. Old foliage is not attacked by the adult sawflies during their egg laying period.

Normally, a healthy tree can lose part or nearly all of the current crop of leaves without being seriously injured. Repeated leaf losses year after year may kill or seriously weaken the tree, risking attack by fungi or by serious pests such as the bronze birch borer. This borer will kill birch trees.

# BLACK VINE WEEVIL

## DESCRIPTION

The adult weevils are about 3/8 inch long and have short snouts. They are black with patches of yellowish hairs on their backs. The weevils appear during June and July and feed on foliage at night. As they cannot fly, a main means of movement is in plants which have been balled and burlapped.

## LIFE CYCLE

Approximately four weeks after they emerge, the adults lay eggs. White, C-shaped grubs hatch and feed on small roots. The mature larvae are creamy white with chestnut brown heads, and are 3/8 to 1/2 inch long. Winter may be passed in either the larval, prepupal, or -- less frequently -- the adult stage.

## DAMAGE

One of the best early indications of the presence of these weevils is the feeding damage done by the adults to the leaves. Characteristic crescent-shaped notches are made on the leaf margins of yew and broadleaved plants. Adult weevils hide during the day under soil and debris at the base of the plant or in the forks of branches. As the infestation progresses, yellowing foliage may be noticed.

Plants infested with black vine weevil often turn off-color and appear unthrifty; newly transplanted stock may die before it can become established. When large numbers of grubs are feeding on the root system, even well-established plants may die, particularly if drought or some other environmental abnormality occurs simultaneously.

# BRONZE BIRCH BORER

## DESCRIPTION

Larva

Female beetle

The adult bronze birch borer is a slender, olive-bronze beetle with a blunt head. It ranges from 1/4 to 1/2 inch in length. The larva is one of the flat headed borers, pearly white in color and about 3/4 to 1 inch in length.

## LIFE CYCLE

Adults emerge in May and early June, depending on seasonal temperatures. The beetles feed for a time on the foliage of birches, aspens, and some willows. After feeding, the females lay eggs in groups under loose flakes of bark or in cracks and crevices in the bark. The young larvae bore into the cambial layer and begin feeding and constructing galleries. This insect overwinters as the larval stage under the bark and pupates the following spring. Hibernation begins when cool fall weather prevails. The life cycle of this insect is completed in one or two years.

## DAMAGE

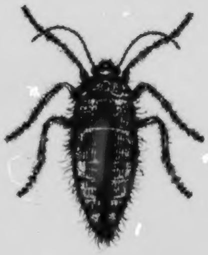
The borers attack paper birch, European white birch, gray birch, poplar, cottonwood and willow. The larval stages injure trees by boring into the trunk and larger limbs, sometimes girdling them. Trees of low vigor and those weakened by drought are most susceptible to attack. The larvae feed in the cambial layer making galleries that wind back and forth usually across the grain of the wood. The tree, or parts of it, are girdled as the larval tunnels interfere with the movement of sap and nutrients in the tree. The tunnels may range up to 5 feet in length. The first signs of damage by the bronze birch borer are the dying back of branches at the top of the tree.

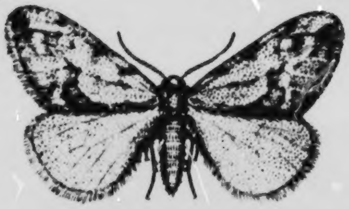
Successful attack usually begins in the crown of the trees in branches about 3/4 inch in diameter. The location of the attack progresses downward year after year. In healthy vigorous trees, the larvae do not complete development and the galleries are healed over causing scar tissue and ridges in the bark.

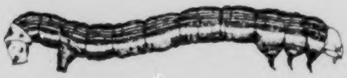
## CANKERWORMS

### DESCRIPTION (Spring)

The male moth has a wing expanse of 7/8 to 1-1/4 inches. The forewings are thin and silky with an ash gray color. The hind wings are similar but paler. The wingless female is nearly 1/2 inch long and generally a dark ash gray with a black dorsal line. Each sex has minute reddish spines in dorsal rows on the abdomen, which give the dorsum a reddish aspect.







The caterpillar has a sooty (grayish-white) white head, mottled with brown, and five pairs of legs. When full-grown, the caterpillars are 3/4 to 1 inch in length, and vary in color from reddish to yellow-brown, green, blue-black or an intermediate color. The broadly oval eggs are a shiny white when first laid, but change to light yellow-brown with age.

### LIFE CYCLE

The moths appear in April and May and lay small irregular clusters of fifty or more eggs in bark crevices on the host tree. Hatching and larval feeding occur in early May, about the same time as with the fall cankerworm. When full-grown, the larvae enter the soil and pupate. The larvae overwinter in a bare earthen cell and pupation occurs in late winter.

## DESCRIPTION (Fall)

The adult male of this species has a wing expanse of about 1 inch. The forewings are a mottled, brownish-gray with hind wings lighter in color.

The wingless female is about 1/2 inch long and an ash-gray color. There are no red spines on the abdomen of either sex as in the spring cankerworm. The full-grown caterpillar has a pale to dark green head capsule which is frequently mottled with black. Its body is about an inch long and varies in color from pale green to brown, black, or reddish-green. Usually there are pale lines running the length of the body and a dark stripe on the back. Six pairs of legs are present, though one pair is quite small and inconspicuous. The cylindrical eggs are gray with brown cap-like tops.

## LIFE CYCLE

The moths emerge from the soil in November and December. The eggs are laid in close-ranked, flat masses of one hundred or more on the bark of twigs and limbs. The overwintering eggs hatch in April and early May as the buds open. The caterpillars feed for 4 or 5 weeks. When full-grown they enter the soil and make tough cocoons of silk and dirt particles near the surface. They pupate in early June, but moths do not emerge to lay eggs until November.

## DAMAGE

The caterpillars of both species appear on trees in early spring. They destroy the young leaves and buds of a wide range of common deciduous trees, but prefer elm and apple. Cankerworms are also abundant on oak in southeastern New York and Long Island. By the time the larvae finish feeding, only the major veins and midribs of the older leaves remain. Trees may be completely defoliated. If this happens 2 or 3 years in succession, trees may die or be seriously weakened. This is an important leaf-feeding pest in areas where Dutch elm disease is present, because defoliation renders an elm very susceptible to attack by the bark beetles that spread the fungus causing the disease.

## EASTERN SPRUCE GALL APHIDS

### DESCRIPTION

Eastern spruce gall aphids produce pineapple-shaped growths 1/2 to 1 inch long, which are usually found near the base of the twig. In early summer, new galls are green with purple or reddish curved markings. Old galls are reddish-brown and have open cavities. Terminal buds are not destroyed until the entire twig dies.

Cooley spruce gall aphids form a larger gall, 1 to 3 inches long, usually covering the entire tips of the infested new growth. Terminal buds are injured quickly. These aphids frequently migrate to Douglas-fir as an alternate host, but do not produce galls on this tree. Severe aphid feeding on Douglas-fir may cause yellowing and crooking of needles and partial needle fall, but normally, little disfiguration (real damage) to the tree results.

### LIFE CYCLE

Only females of the eastern spruce gall aphid are known to occur. Immature females winter on twigs, usually near the terminal buds. In early spring, the insects begin feeding; when mature, they produce a conspicuous waxy cover under which they lay a mass of eggs. The eggs hatch in a week and the young insects start feeding at the base of the developing needles. Continued feeding induces abnormal growth at the bases of the needles until the aphids are entirely enclosed in a gall of plant tissue. Here the insects complete their development.

Galls and aphids mature in mid-summer. The gall dries and splits around the deformed needle bases and the aphids emerge. These young females shed their skins, develop wings and fly to the needles of the same or another spruce tree. They lay eggs at the base of the new buds.

Immature females of the Cooley spruce gall aphid winter on spruce or Douglas-fir and produce a waxy covering in the spring. The egg masses are laid under this covering which resembles a small cottony mass. These are conspicuous on the twigs. The eggs hatch and the young insects crawl to the developing buds and begin to feed at the base of the new needles, eventually forming a gall. During middle to late summer, the gall opens and the mature aphids emerge. Some females may migrate to Douglas-fir to lay their eggs. The eggs hatch and the young insects winter there. In the spring, they feed on the needles, mature and lay eggs. These hatch and develop into adults that remain on the fir or fly back to spruce to lay eggs for a new generation. The presence of Douglas-fir is not necessary, however, as the aphids can maintain themselves on spruce alone.

### DAMAGE

Galls interfere with the natural formation of twigs, causing curling, stunting, and the eventual death of new growth. Heavy infestations give the trees a ragged appearance, destroying their beauty. Some trees have a natural resistance or immunity to these aphids, and in spite of the presence of the insects, the galls never completely develop or may not form at all.

## ELM BARK BEETLES

### DESCRIPTION

Two species of small (1/8 inch), reddish-brown bark beetles are common pests of elm trees. They overwinter under the bark as either larvae or adult beetles.

### LIFE CYCLE

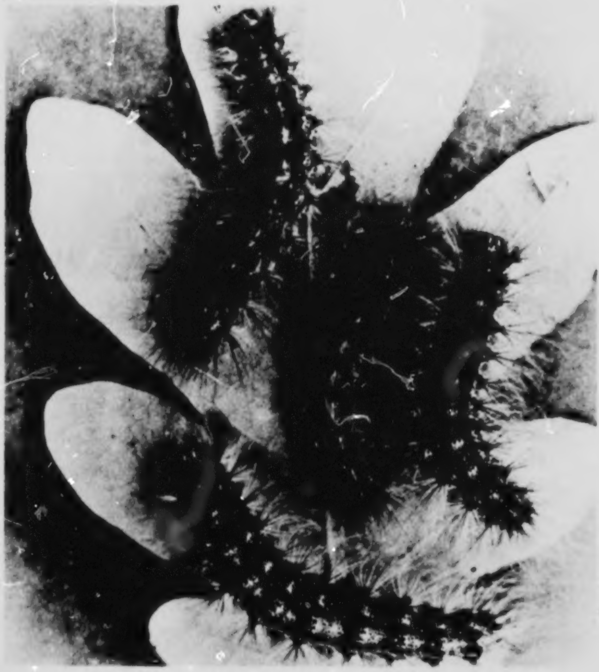
Emergence starts in May when the beetles fly to healthy elm trees to feed on the bark in the crotches of twigs. This feeding process spreads Dutch elm disease to healthy trees. After feeding on healthy trees, the beetles lay their eggs in dead or dying trees.

## DAMAGE

Evidence of bark beetles breeding in dying and dead trees will show up as small shot-holes in the bark or the many-branched gallery pattern etched on the inner bark and surface of the wood. If bark beetles were not vectors for Dutch elm disease, damage to healthy trees would be slight.

## GYPSY MOTH

### DESCRIPTION



The female moth is nearly white with yellow to buff hairs on the abdomen. The forewings are marked with irregular blackish bands. There is a line of black dots near the outer edge of the wings. The wingspread is about 2 inches. The female does not fly.

The male moth has a brown body and light to dark brown wings with black markings. Its wings expand to about 1-1/2 inches. It is a strong, day flier, and follows a zigzag flight pattern.

The eggs are deposited in masses of 100 to 700 or more and covered with the buff to yellowing hairs from the abdomen of the female. These egg masses are normally about 1-1/2 inches long and about 3/4 of an inch wide. In fresh egg masses, the surface feels like velvet and when the mass is opened the eggs feel like buckshot when they are touched. The fresh masses tend to have a more "lively" color than the older ones, which may present a bleached-out appearance or be otherwise "off color" from weathering.

The hairy caterpillar of the gypsy moth has a dusky to sooty colored or slate-colored body, and on the back, behind the head, a double row of blue spots (5 pairs) followed by red spots (6 pairs). When mature it is from 1-1/2 to 2-1/2 inches long.

## LIFE CYCLE

The female lays her eggs during late July or August. The egg masses are deposited on undersides of branches, tree trunks, under loose bark, in stone walls, on fences, or any shady, protected place. The insect overwinters in the egg stage.

The following spring the larvae hatch about the time the trees are coming into leaf in early May, at about the time serviceberry (shadbush) is in bloom. The newly hatched caterpillars spin silken threads on which they may be borne long distances by wind. While young they eat "pin holes" in leaves of preferred plants. As they become larger, the larvae devour all green plant material on the host plants. In about seven weeks, or by early July, they are fully grown and seek a place to pupate. They spin a few strands of silk, and transform to the pupal or resting stage. In about 7 to 17 days, the moths emerge. The males usually appear earlier than the females. There is one generation each year.

## DAMAGE

Tree species preferred by the larvae of gypsy moth are oaks, willows, poplars, speckled alder, basswood, apple, gray birch and river birch. Less favored but also eaten by the larvae are the cherries, elm, hickories, chestnut, hornbeam, maples, sweet birch, paper birch, yellow birch, sassafras, black tupelo, and larch. Older larvae will eat native eastern pines and spruces, southern white cedar, hemlock, and beech.

Species disliked by the larvae are black walnut, butternut, ash, catalpa, flowering dogwood, American holly, yellow poplar, locusts, sycamore, red cedar and balsam fir.

One complete defoliation will not usually kill thrifty hardwoods but may be fatal to conifers. However, repeated defoliation of hardwoods will reduce their vigor so that other insects and disease-producing organisms may cause the death of some of the trees. Tree losses have been noted after only one or two years of complete defoliation during drought periods on poor sites, and openings in the forest sometimes result.

The aesthetic, recreational, and watershed values of forest, park and ornamental trees can be seriously threatened by this pest. The hoards of caterpillars that occur during outbreaks create a public nuisance.

## JAPANESE BEETLE

### DESCRIPTION

The beetles are about 1/2 inch long with metallic-green bodies, coppery-brown wing covers, and six small patches of white hairs along the sides and on the back of the body. They overwinter as grubs under the soil surface, pupate in late May and in June, and begin to emerge as adults in late June.

### LIFE CYCLE

The Japanese beetle has a complete generation each year and spends about 10 months of the year in the soil as a grub.

The adult beetles start emerging from the soil during the last week of June and increase in numbers until they reach their peak in late July. Emergence drops off sharply about mid-August, but a few beetles may still be around through September.

The female beetles deposit their eggs in moist soil. The eggs need ample moisture to promote hatching. Dry soil conditions during July and early August are not attractive to the females for egg deposition and hinder hatching of the eggs. Eggs normally hatch in about 10 days.

The tiny grubs start feeding on humus immediately. As they increase in size, they move close to the soil surface and start feeding on grass roots. They grow rapidly and will be about 1 inch long by late September. Most injury occurs during the fall and early spring as the mature grubs feed near the surface.

The Japanese beetle grub can be distinguished from other grubs by the arrangement of hairs on the raster.

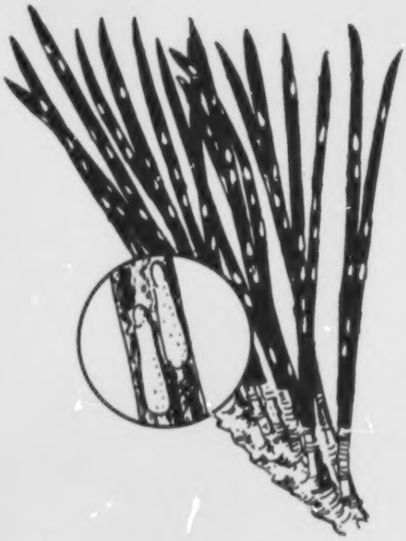
When the soil temperature starts to drop in the fall, they move down 6 to 12 inches in the soil where they overwinter. In April they move back up to the root zone and continue feeding. In late May and June they change to the pupal stage and start emerging as adult beetles in late June.

## DAMAGE

The adult beetles are active during warm, sunny days from early July until September. The beetles feed on the flowers and foliage of shade trees and ornamentals, leaving the veins of the leaves untouched. Although this feeding seldom kills a plant, the brown, damaged leaves are unsightly.

# PINE NEEDLE SCALE

## DESCRIPTION



Adult male scales are pure white, about 1/25 of an inch long and have a single pair of wings. The males are active fliers and appear late in the summer.

The mature female scales are about 1/10 of an inch in length. They are elongate, sedentary, nearly white and possess a small orange, nipple-like structure at one end. The scale widens toward the posterior end giving it a pear-shaped appearance.

## LIFE CYCLE

The purplish-red eggs are deposited on the needles in late August and September, and the insect passes the winter in the egg stage under the female scale. In New York State the eggs hatch during mid-May or early June, depending on locality and weather conditions.

The young nymphs (called "crawlers") are lemon-yellow in color and possess well developed legs and antennae. They may hatch and remain under the parent scale if the temperature is low. On warm days they crawl out from under the scales and migrate to young needles where they wander for a few hours. After the nymphs molt once they lose their legs and settle down on the needles to feed. Growing slowly, the insect reaches maturity by late July or early August.

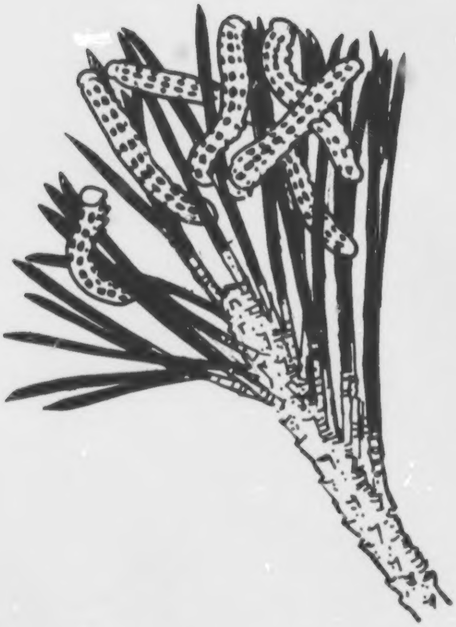
In the extreme southeastern areas of New York State, the eggs laid by the females of the first generation hatch and the young emerge in late July or early August. By early October the second generation females deposit eggs that overwinter. Elsewhere in Upstate New York there is but one generation per year.

## DAMAGE

Sap loss in the needles caused by the sucking actions of these insects may weaken trees and give them a pale green, sickly appearance. The foliage turns yellow and mottled and if unsprayed the needles eventually turn brown and drop. Uncontrolled infestations gradually kill branches and sometimes the entire tree.

## PINE SAWFLIES

DESCRIPTION (Red Pine Sawfly)



The larva prefers red pine but it will feed on jack, mugho and Japanese red pines. At times older larvae feed on white pine that is growing in close association with red pine.

When full grown the larva is about 3/4 inch in length, and the body may be grayish green to black on the back and greenish white on the underside. The mid-dorsal stripe is light green, bounded by a lighter stripe above and below on each side and it extends the length of the back. A blackish stripe is present at the base of the legs. The thoracic legs are also black with whitish rings. Prior to pupation, the head, usually black, may turn yellowish brown. In addition, the four longitudinal stripes become more distinctly blackish.

LIFE CYCLE

There is one generation annually. The insect spends the winter as an egg in the needles. The larvae emerge in May and usually complete their growth by June before the current year's needle growth is completed. They pupate in the litter near the base of the trees. The adults emerge during September and October.

DESCRIPTION (Red-Headed Pine Sawfly)

This is one of the most widespread and destructive of the native species attacking pine trees. It is often abundant in northern New York State on red pine. Pines having needles in clusters of two to three are preferred. Host plants are red, pitch, Scotch, Austrian, mugho, jack, loblolly, slash, Japanese red and Virginia pines. Occasionally Eastern white pine may be attacked.

Newly hatched larvae are whitish, faintly marked and have brownish heads. After molting, the bodies become yellowish white with six rows of conspicuous black spots that extend the length of the insect, and the head turns reddish. The larvae are fully grown in 25 to 31 days and average 7/8 to 1 inch in length. When ready to pupate, they drop to the ground and spin tough, reddish brown capsule-shaped cocoons 5/16 to 7/16 inch long in the top soil.

## LIFE CYCLE

The life history is complicated as there may be more than one generation a year. Sometimes prepupal larvae remain dormant through one or two years. Broods of larvae may be found feeding from spring until late fall.

## DAMAGE

In the larval stage the insects are caterpillar-like with three pairs of thoracic legs and eight pairs of legs on the abdomen. They usually feed in groups and strip one branch of needles before they move on to another branch. They prefer old needles but may eat new needles later in the summer or when food is scarce. The feeding pattern varies with the species, but in most cases, severe defoliation will kill the trees.

When mature, the larvae spin tough capsule-like cocoons in the forest litter in or on the ground and sometimes on the tree. The wasp-like adults emerge and lay eggs singly in slits cut in the needles of the host tree. These slits are cut by a saw-like ovipositer used to deposit the eggs, hence the common name sawflies.

## SPIDER MITES

### DESCRIPTION

In New York State, there are over 40 species of spider mites involving nine genera, of which only a few species become economically important. Some genera of mites display distinct feeding habits since certain species are usually attracted to specific plants. Identification of the pest species can often be made in the field by knowing these characteristics. The following guide may be useful in their identification:

1. On Conifers, particularly spruce, hemlock, cedar (arborvitae) and juniper; Spruce mite.

2. On Broadleaved Plants, with mites feeding and damaging the upper surfaces of the leaves:

   Oak mite on oak

   European red mite on elm, mountain-ash and most fruit trees (apple, cherry, etc.)

   Clover mite on many hosts including elm, apple, many shrubs and weeds.

3. On Broadleaved Plants, with mites feeding and damaging the undersurface of the leaves:

   Locust mite on honey locust

   Two-spotted spider mite. This mite has an extremely wide host range and is the most common spider mite encountered. There is a noticeable green area on each side of its body.

## LIFE CYCLE

Members of the genera Oligonychus and Panonychus overwinter as eggs on the twigs: locust mite and two-spotted spider mite overwinter as adults hiding on twigs and bark or in duff at the base of trees: Bryobia overwinters in all but the egg and larval stages on or near the trunks of trees.

Spider mites can complete a life cycle in about 10 days depending on weather conditions. Rapid population growth is possible and if unchecked may infest all available leaf tissue of the plant. A rapid population decline usually follows. Development follows from egg, larva, two nymphal stages, and the adult, all of which may be found at the same time on the tree due to overlapping generations.

## DAMAGE

Spider mites receive their name from their ability to spin a fine web over the leaves of the host plant. At times the entire foliage of the plant may be covered by this webbing. Close examination of the leaves may show numerous, small, light-colored to brown spots, characteristic signs of feeding areas of the mite. As damage increases, leaves or needles may drop or appear distorted. Since mites are very small, it is difficult to see them readily with the naked eye. Holding a piece of white paper under the foliage and shaking the plant will dislodge the mites which will appear on the paper as very tiny reddish or dark spots scurrying about. Mites, other than spider mites, may also be found.

The degree of damage to the trees will vary depending on the species of mites involved as well as the species and condition of the host plant. In general, newly transplanted nursery stock may be seriously affected. Under forest conditions, spider mites do not usually build up to serious levels, but on some species of shade and ornamental trees the pest may become a serious menace due to poor growing conditions of the tree or shrub, absence of natural enemies, spray materials previously used, or drought.

## WHITE PINE WEEVIL

### DESCRIPTION

An adult white-pine weevil is about one-fourth inch long. The insect is characterized by a distinctive tapered head with a slender protruding beak-like snout. The antennae are located at or just behind the middle of the snout; at its base the eyes are widely separated. The body is covered with tiny reddish-brown and white scales with a distinct irregular patch of grayish-white scales near the rear of each wing cover.

The larva is legless, creamy white in color, and slightly longer than the adult weevil. The head of the larva is small and light brown with distinct eye spots. Larvae are found under the bark or in the wood of a weeviled shoot.

The pupae are creamy white with brown eye spots. The abdominal tip is square. As the pupae approach maturity the beak and legs begin to turn brown and the general color of the adult is assumed. The pupae are about the same length as the adults.

### LIFE CYCLE

The white-pine weevil has one generation a year. Adult weevils hibernate in the ground litter near the base of host trees. In New York State the weevils usually become active during April -- about the time the buds on the white pine begin to swell. On leaving the litter they crawl up or fly to the vertical terminal shoot of the host tree and feed on the inner bark tissue. Egg laying may start as early as mid-April in the southern counties of the state and extend through June in the more northern counties. A single terminal shoot may contain from 20 to over 350 eggs, depending upon the number of females laying eggs. The female may visit more than one leader to deposit her eggs and any single leader may contain eggs deposited by several female weevils. Resin flows over the bark and eventually fills the chambers containing the eggs. Exposure to the air hardens the resin and acts as a sealing agent. The eggs hatch in five to ten days.

The larvae feed at the juncture of bark and wood, destroying the cambium and inner bark tissue in their downward progress. As they mature they tunnel into the wood and pupate in the pith. Others may pupate in shallow cavities chewed out in the surface of the wood; the cavities are covered with the excelsior-like strips of wood removed in excavation. These are the chip cocoons.

Larvae in different stages of development may be found in leaders as egg laying occurs over a month's time. As a result emergence may span from June to September.

## DAMAGE

The important external symptoms of attack are confined to the leader and differ depending on the time of year observations are made.

In the spring when adults are feeding, mating, and laying eggs, glistening water-like resin droplets may be observed on the leader for a distance of several inches below the terminal buds. Oozing from the feeding punctures, the resin dries and turns whitish. The new terminal growth of attacked leaders is darker green than normal. As the season progresses the new growth wilts and assumes the form of a shepherd's crook; it dries and turns brown. The bark of the stem below the new growth turns from green to brown as the larvae, feeding under the bark, progress downward. By mid-summer, in most localities, the needles on the killed portion have turned yellowish to brown. At this time, or shortly after, the new generation of beetles exists under the bark. They escape to the outside by chewing BB-shot sized holes through the bark. These holes, with chip cocoons under the bark, dried resin, withered stem, and browned foliage identify the injury as that of the white-pine weevil.

Variations of the typical symptoms do occur. If adult feeding on the leader in the spring is very heavy, the leader may be girdled and the terminal buds produce no new height growth.

If feeding is less severe, shoot elongation occurs but is much shortened. These aspects of injury may or may not be associated with larval feeding. In some cases, adult emergence holes may be lacking as larvae are killed by an abundant flow of resin. The leader may be killed or portions of it may be destroyed without killing the entire leader. Scars of callus tissue indicate the latter situation.

## SUMMARY OF SOME INSECT PESTS ON ORNAMENTAL PLANTS

| Name of Pest | Type of Feeding | Plant Type Attacked | Plant Parts Attacked | Life Stage Causing Damage | Life Stage(s) Best Controlled by Insecticide | Injury Diagnosis | Insect Recognition |
|---|---|---|---|---|---|---|---|
| aphids | sucking | many deciduous and evergreen plants | leaves, twigs, branches trunk | nymphs and adults | nymphs, adults | leaves and lower portions of plant covered with honeydew and/or sooty mold. | small, soft-bodied insects. Colors vary. Usually abundant and without wings. |
| birch leaf miner | chewing | birches | foliage | larvae | larvae | mined and browned foliage | adults are small, black sawflies. Larvae are whitish, found inside foliage. |
| black vine (Taxus) weevil | chewing | yew, rhododendron, arborvitae, hemlock | roots (larvae) and foliage (adults) | larvae and adults | adults | roots destroyed or girdled by larvae; foliage notched at margin by adults. | larvae are small, white grubs; adults are brownish-black weevils. |
| bronze birch borer | boring | birch<br>poplar<br>cottonwood<br>willow | twigs, branches, trunk | larvae | adult | die back of branches at top of tree. Brown stain where holes appear on trunk. | adult, slender, olive-bronze beetle with blunt head. Larva-flat head, pearly white in color. |
| cankerworms | chewing | deciduous plants | foliage | larvae | larvae | chewed foliage | colors vary. Size approximately 1" long. |
| Eastern spruce gall aphid | sucking | spruce, especially Norway and White | bases of expanding buds | nymphs | nymphs, adults | cone like gall at base of new growth | light green with waxy "threads". |

Insect Pests on Ornamental Plants (Cont'd.)

| Name of Pest | Type of Feeding | Plant Type Attacked | Plant Parts Attacked | Life Stage Causing Damage | Life Stage(s) Best Controlled by Insecticide | Injury Diagnosis | Insect Recognition |
|---|---|---|---|---|---|---|---|
| elm bark beetles | chewing | elm | crotches of twigs | larvae, adults | adults | adults transmit Dutch elm disease which shows up as "flagging" of foliage. Foliage drops in early summer. | adults are small, reddish brown beetles. Larvae are small, whitish, legless grubs. |
| gypsy moth | chewing | deciduous plants | foliage | larvae | larvae | foliage chewed | larvae hairy and ± 2 inches long when mature. Color is greyish, behind the head is a double row of blue spots (5 pairs) followed by red spots (6 pairs). |
| Japanese beetles | chewing | many shade trees and ornamentals | foliage | adults | adults | chewed foliage, leaving veins of the leaves untouched. | adult, metallic green bodies, copper-brown wings, 1/2 inch long. |
| pine needle scale | sucking | many pines and spruces | foliage (needles) | nymphs, adults | young nymphs, eggs | needles turn yellow, then brown before dropping off. Lower branches may die. | white covering over individual insects. Large numbers of insects on needles. |
| pine sawflies | chewing | pines | foliage (needles) | larvae | larvae | chewed needles | larvae have 3 pairs "true" legs and 8 pairs of "fleshy" legs on the abdomen. |

Insect Pests on Ornamental Plants (Cont'd.)

| Name of Pest | Type of Feeding | Plant Type Attacked | Plant Parts Attacked | Life Stage Causing Damage | Life Stage(s) Best Controlled by Insecticide | Injury Diagnosis | Insect Recognition |
|---|---|---|---|---|---|---|---|
| spider mites | sucking | many deciduous and evergreen plants | foliage | nymphs, adults | all | general discoloring, small brown spot wherever feeding took place. | yellow to red color, approximately pinhead size. |
| white pine weevil | chewing | pines, Norway spruce | leaders | larvae, adults | adults | browned foliage, dead leaders; and/or resin droplets on leaders. Crook in main stem. | larvae are small, yellowish, legless; adults are small, brown weevils. |

## APPLE SCAB

### SYMPTOMS

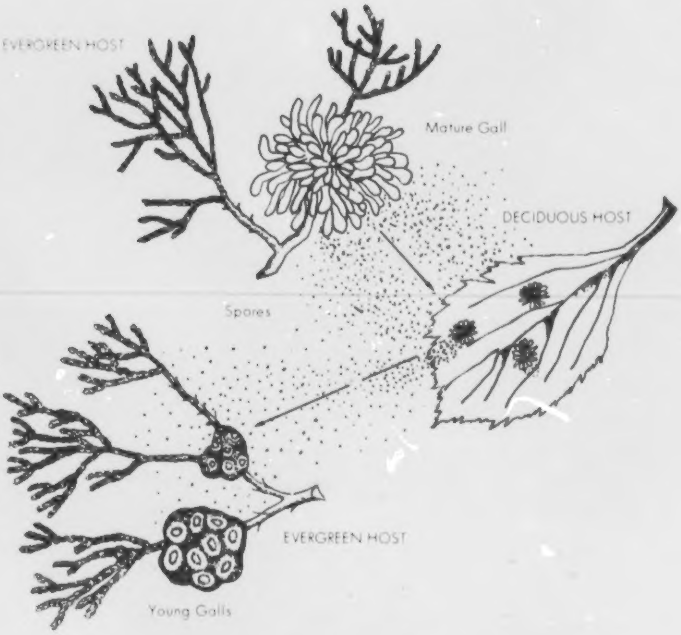
Apple scab may affect leaves, petioles, pedicels, fruit and occasionally twigs. The diseased area first appears as an indefinite olive-green spot and may appear on both sides of the leaf while the bud is developing. Later infections may appear on the upper surface only. As the infected tissue ages, the lesion becomes more definite in outline and is covered with a greenish-black, velvety growth. This later disappears becoming a raised area. Severe infections result in a curling and twisting of the leaf. Heavily infected fruit is misshapen, frequently cracked open, and it may drop prematurely.

### LIFE CYCLE

The disease is caused by a fungus, Venturia inaequalis (imperfect stage). The fungus overwinters in fallen leaves from which spores are produced in early spring when apple buds are developing. A combination of rainfall and temperatures favorable to infection can result in severe outbreaks of the disease throughout the early part of the growing season. Once the olive-green spots appear on a young leaf, spores are produced and spread by wind and rain resulting in new infections which may persist throughout the growing season.

## CEDAR-APPLE RUSTS

These rusts require two different plant hosts for completion of the disease cycle. Part of the cycle is spent on eastern red cedar and its relatives in the genus Juniperus; the remainder is spent on apples and related members of the rose family.



LIFE CYCLE OF CEDAR RUST

### SYMPTOMS

Upon evergreen hosts these rust fungi cause either swelling of twigs and small branches or definite gall-like growths which may enlarge to as much as two inches in diameter. During rainy weather, yellow, gelatinous, finger-shaped bodies protrude from the galls, and tiny slimy cushions from swollen twigs. These structures, known as spore horns, produce fungus spores. The spores are carried by air currents and are capable of establishing the fungus on the alternate broadleaf hosts.

The rust fungi invade the leaves and fruits of the broadleaf hosts, causing them to become discolored and often deformed. Spores of another type are formed on the underside of the infected leaves and upon the fruits. These spores are windborne and spread the fungus to nearby susceptible evergreens of the juniper group.

The fungi usually live only one season in the foliage, fruit, or twigs of a broadleaf host but persist for two or more seasons in tissues of the junipers.

### LIFE CYCLE

Cedar-apple rust is caused by a fungus. On junipers and red cedar (Juniperus species), the rust fungi usually do little harm. At most, rust can make them unsightly. Cedar-apple rust fungi must also attack foliage, fruit or succulent twigs of apples and related woody plants in order to complete their life cycle. These alternate hosts are essential for survival and intensification of the disease on coniferous hosts. Many of the alternate hosts are valuable ornamental and horticultural trees and shrubs which may be severely injured by the rust fungus.

The common coniferous hosts are Juniperus communis, J. horizontalis, J. sabina, J. sibirica, J. scopulorum, J. virginiana, and many of the other varieties. The alternate hosts include ornamental crab, pear, quince, mountain ash, chokeberry, Juneberry, hawthorn, and members of the apple group, including cultivated forms.

The fungi which cause cedar-apple rusts are classed in the genus Gymnosporangium. Three of these fungi, Gymnosporangium juniperivirginianae, G. clavipes, and G. globosum, cause apple rust, quince rust, and hawthorn rust respectively in New York State.

These fungi live within the tissues of their hosts and reproduce by means of spores. The fungi are unable to spread from juniper to juniper or from one broadleaf host to another but must alternate between the two kinds of plants. That is, the spores produced by a rust fungus on eastern red cedar or juniper can cause the disease only on a broadleaf host and vice versa. If either host is absent, the fungus cannot spread and will eventually die.

## DAMAGE

No serious harm results ordinarily to coniferous hosts from the presence of the rust fungi. Heavily infected eastern red cedars may become somewhat unsightly due to the presence of many brown galls and dead branch tips. Similarly, spots and deformities of leaves, fruit and twigs of crabapples, hawthorn and related hosts can be unsightly when heavily infected.

## CYTOSPORA CANKER OF SPRUCE

The cause is a fungus, Cytospora kunzei.

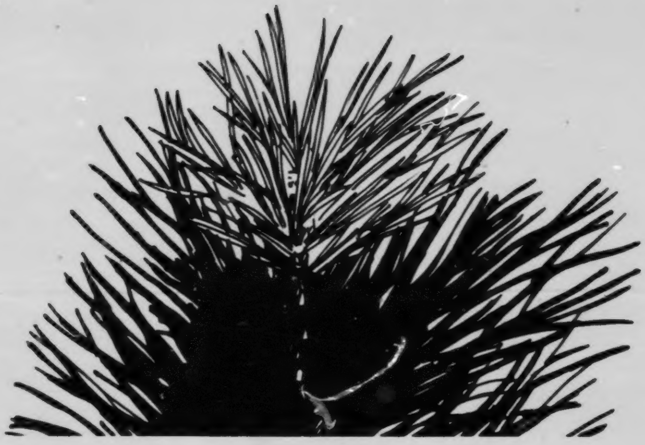
### SYMPTOMS

Killed branches and excessive production of resin or pitch are characteristic of spruce canker. After the causal fungus has become established, the infected bark, before death, produces resin in great abundance. Droplets of the fresh resin ooze from the infected bark during the growing season, and in warm weather drip from branches or flow down the trunk, forming almost a solid coat of pitch over the diseased and adjacent healthy bark. Careful observation of bark cut from a canker may show black spherical bodies about the size of very fine shot buried just beneath the surface. During damp or wet weather spores exude from these spherical bodies. These spores are able to initiate new infections.

Dead and dying branches are usually the first evidence of disease noticed by the owners of the affected trees. Colorado and Koster blue spruces are most heavily damaged. Trunk cankers may occur on any host, but branch cankers are most common. Infected branches die from the canker outward, thus, the first conspicuous evidence of disease is often the appearance of one or several dying or dead branches. Cankers and dead branches are apt to appear in the lower part of a tree and very commonly spread upward along one side in the early stages of the disease. When infected bark is cut away, the margin of a canker can be determined by the dark-colored, resin-impregnated wood beneath the cankered bark, in contrast with the light color of the surrounding healthy wood.

Cankers are restricted usually to spruce more than 15 years old.

## DIPLODIA TIP BLIGHT OF PINE



Dead tips of otherwise healthy pine branches may indicate tip blight caused by the fungus Diplodia pinea. Austrian pine is the most highly susceptible pine affected in New York. White pines are quite resistant. No species of pine, however, is immune. In many cases, severe infections year after year have greatly weakened and even killed large trees such as Austrian pines.

### SYMPTOMS

A few stunted brown needles or dead, resin soaked candles (new shoots) in the current season's growth are the first evidences of tip blight. These symptoms are usually located on the lower branches of the tree. Needles that are in the early stages of development stop growth after infection and therefore appear stunted when compared to healthy needles.

Infected twigs are often girdled by cankers, stunted or deformed and may exude resin which traps blighted needles before they fall to the ground. In most cases, these symptoms are not observed beyond the current season's growth.

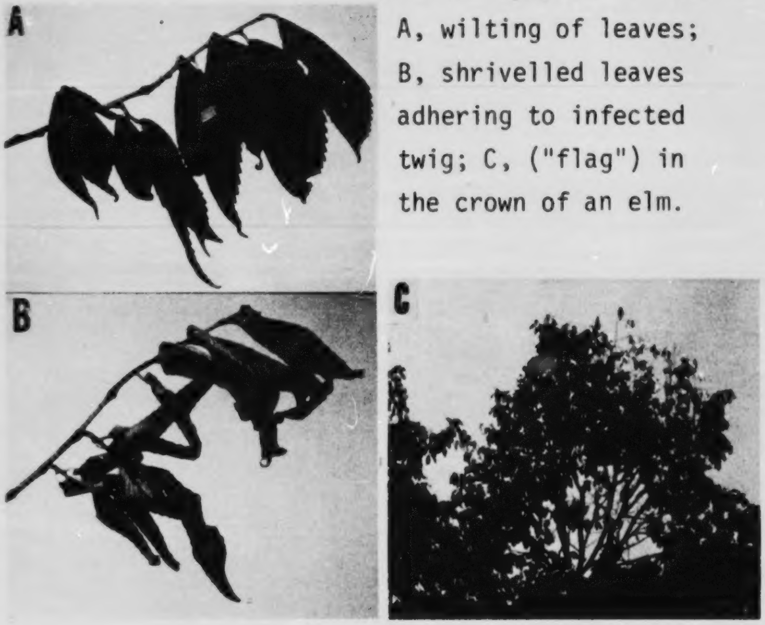
With a hand lens you may see minute black fruiting bodies (pycnidia) on infected cones and on the bases of diseased needles, especially in the leaf sheath.

### LIFE CYCLE

The causal fungus is present throughout the year in dead needles, leaf sheaths, twigs and cones located either on an infected tree or on the ground. Small black fruiting bodies mature during late spring or early summer in this material. The brown oval spores ooze out of the fruiting structure during wet conditions and are scattered by wind, splashing rain, animals or pruning equipment. Some spores land on young shoots and needles of the current season's growth. After the spore germinates, the fungus enters the shoot. A few hours later, a brown area develops near the point where the fungus entered. The progressive invasion of the twig by the fungus results in browning of the attached needles and canker production in the twig.

## DUTCH ELM DISEASE

### SYMPTOMS



Foliar symptoms of DED: A, wilting of leaves; B, shrivelled leaves adhering to infected twig; C, ("flag") in the crown of an elm.

Leaves of elms hang down ("wilt" or "flag"), then curl and dry out. They may or may not fall from the tree. Commonly, one side of the tree is affected first. The alert tree-owner may notice the wilt when it first appears in leaves of small twigs, at which time the disease can still be removed by drastic pruning. Affected trees usually die within a year but occasionally a large tree takes several years to die. Current sapwood contains scattered, brown, longitudinal streaks which may show in the cross-section of a cut branch as a circle of brown dots just under the bark or may merge to form a brown ring.

The symptoms are identical to those of other wilt diseases (for example, Verticillium wilt), so one can be certain of the diagnosis only by seeing which fungus grows from the wood in a laboratory culture. However, in areas suffering epidemics of Dutch elm disease, these minor disease fungi usually constitute only about one percent of the isolates. The symptoms are sometimes confused with those of another elm disease, phloem necrosis, or drought injury or feeding by the elm leaf beetle; however, in these cases, there is no discoloration in the sapwood.

Dutch elm disease is caused by a fungus named Ceratocystis ulmi, which is carried from tree to tree in America by a European elm bark beetle, Scolytus multistriatus, and the native elm bark beetle, Hylurgopinus rufipes. Also, the fungus may pass directly from tree to tree, through root grafts which occur commonly when trees are spaced closer than about 30 feet apart.

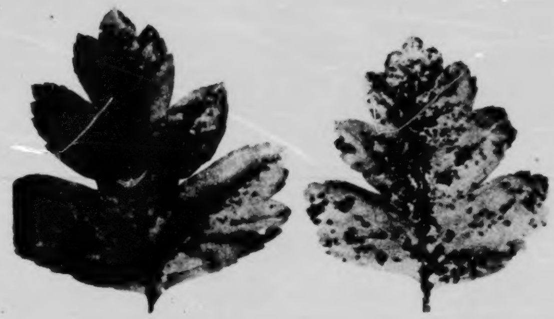
## LIFE CYCLE

The fungus overwinters in dying and dead elms, growing and producing its sticky spores in the tunnels of the elm bark beetles, between bark and wood. The beetles also overwinter in dead and dying elms, as larvae, pupae, or adults. In the spring, the bark beetles mature and then fly to feed on the young bark of nearby healthy elms -- usually no farther than about 1/4 mile, unless, on occasion, they are carried farther by wind or automobiles. Elms are most susceptible to infection in May and June although infections can occur later in the summer.

The sticky spores of the fungus adhere to the outsides of the beetles, and are smeared into the wounds made by the feeding (in twig crotches or under the bark of young branches). The beetles then fly away and mate after seeking a dying elm in which to lay their eggs -- no other place will do.

The fungus-infested beetles contaminate the elm wood where eggs are laid with the Dutch elm disease fungus. Thus, the next generation of adult beetles emerges contaminated, whether or not the elm where they matured was killed by Dutch elm disease.

## HAWTHORN LEAF BLIGHT



Hawthorn leaf blight, caused by the fungus Diplocarpon maculatum, first appears as a leafspot in early summer. English hawthorn, Crataegus oxyacantha and Paul's scarlet hawthorn, C. oxyacantha 'Pauli' are more susceptible to this disease than are other hawthorns. Severely infected trees may be totally defoliated by mid- or late-August of wet seasons. Diseased trees, weakened after a few years, succumb more easily to adverse weather conditions and other pathogens.

### SYMPTOMS

The initial symptoms appear in June as small, angular red-brown spots (1-4 mm or under 1/4 inch in diameter) predominantly on the upper leaf surface. As the spots enlarge, they coalesce, gradually covering more of the leaf surface. Infected leaves yellow and fall prematurely.

With a hand lens, numerous small, black circular spots can be seen in the leaf lesions. These spots are the fruiting bodies of Diplocarpon maculatum.

Sunken lesions, initially 1/16 inch in diameter, develop on the petioles and new shoots. These lesions, called cankers, become elongated and sometimes girdle the shoot.

### LIFE CYCLE

Diplocarpon maculatum, the fungus responsible for this blight of hawthorn, overwinters on the ground in leaves killed by the disease. Late in spring, mature fruiting bodies of the fungus release microscopic spores into the air for about 1 - 2 weeks. These spores are carried by air currents to hawthorn leaves where infections may take place. (After a mild winter, fruiting bodies and spores may develop in cankers on the diseased trees.) By mid-July the fungus in spotted leaves produces spores that cause more infections. Eventually diseased leaves fall to the ground and, after a cold winter, serve as a source of this fungus again the following spring.

## JUNIPER TWIG BLIGHT

Juniper twig blight is caused by the fungus Phomopsis juniperovora. This disease is devastating to young trees and hedges; trees more than 5 years old are less seriously damaged. Many species of juniper, arborvitae, white cedar, cypress and false-cypress are susceptible.

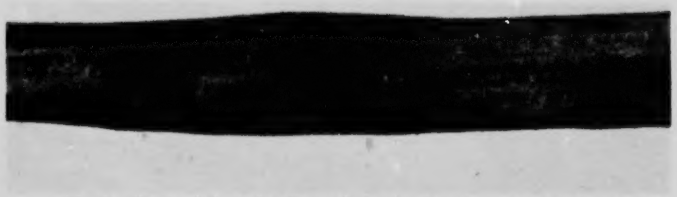
### SYMPTOMS

Blight symptoms first show up on current growth. Shoot tips die back toward the main stem. If moist weather favors a build-up of infection for several years, death of the shrub may result. Drought, winter kill, male dog injury and transplant shock can cause similar die-back symptoms. However, the small black fruiting bodies of this fungus (up to 0.5 mm in diameter) present on recently killed leaves and stems are diagnostic for juniper twig blight.

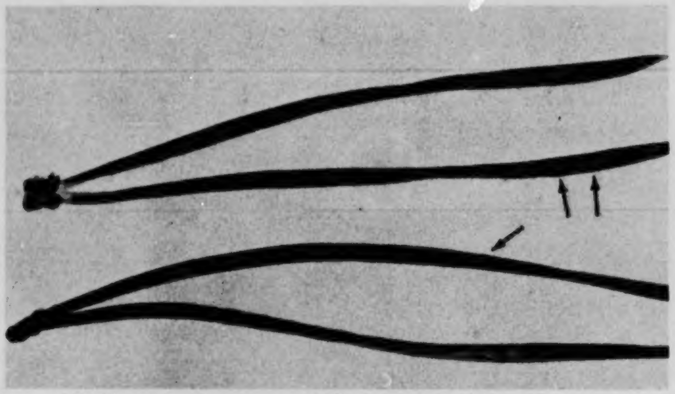
### LIFE CYCLE

Phomopsis juniperovora overwinters in killed twigs and bark on the tree or on the ground. Fruiting bodies of the fungus develop in the spring and, during wet weather, release many microscopic spores capable of causing new infections. The fungus attacks young succulent shoot tips and may also enter the plant through wounds. If wet seasons prevail, it will spread throughout the shrub in the course of a few years or less.

## LOPHODERMIUM NEEDLE CAST OF PINES



**Black elliptical fruit bodies of *Lophodermium* on dead needles**



**Needle cast symptoms — yellow spots with brown centers**

Several kinds of plant pathogenic fungi cause death and premature casting of pine needles. One of these pathogens, a species of Lophodermium, causes significant damage in New York State Christmas tree plantations. Short-needle varieties of Scots pine, especially the Spanish and French-green types, are the most susceptible.

### SYMPTOMS

Prominent symptoms appear in spring when 1-year-old needles die and turn straw colored. In spring and early summer the dead needles fall from the twigs. If infection is severe, nearly all 1-year-old needles may be cast. With repeated severe infection, trees become stunted. Within only a few years, the fungus can spread from a single infected tree to nearly all trees in a plantation. Many individual trees seem naturally resistant; they remain green while adjacent trees become heavily infected.

Infection occurs once annually in late summer and early autumn. At that time microscopic spores of the fungus are produced in tiny, black, elliptical fruit bodies in dead needles, either lodged among branches of the tree or, usually, lying on the ground. In wet weather the spores are ejected into the air. Those landing on current-season pine needles germinate, and the fungus grows into the needles. The first symptoms are inconspicuous yellow spots. These enlarge and intensify during the autumn and winter, developing brown centers and then coalescing. Infection is usually most severe on the lower branches because they are close to the source of spores, and moist conditions favorable for infection occur more frequently and last longer close to the ground.

# RHABDOCLINE NEEDLECAST OF DOUGLAS-FIR

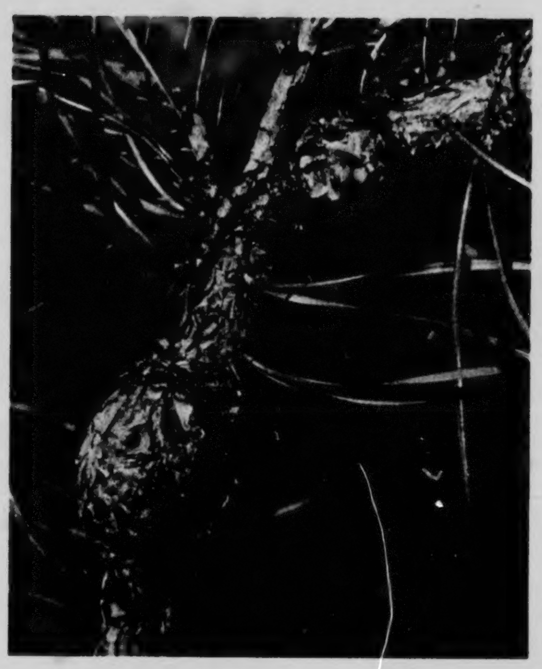
Fungi in the genus Rhabdocline cause purple-brown spotting and premature casting of needles of Douglas-fir in Christmas tree plantations and occasionally in nurseries. The disease does not often occur on ornamental Douglas-firs in landscapes.

## SYMPTOMS AND DISEASE CYCLE

Beginning in autumn and winter, purple-brown spots 1 - 2 mm across develop on green 1-year-old needles. When numerous, the spots coalesce. The base of each infected needle stays green. From late winter into June, infected needles fall. Tiny blisters less than half the width of the needle develop in May on the lower surfaces of brown spots on infected needles still on the tree. The blisters, the same color as the spots, are sources of spores that are carried by air currents to developing foliage. The spores germinate and cause new infections in May, but no new symptoms show until the purple spots begin to develop again in autumn. In summer the only symptom may be absence of needles from 1-year-old twigs. Repeated severe infection will destroy the economic value of a Douglas-fir Christmas tree.

## CONDITIONS THAT SUPPRESS DISEASE

Rhabdocline needlecast is favored by moist conditions and poor air circulation around low branches. Plantations on slopes and where weeds are controlled are least likely to be seriously damaged. The pathogen can mature and produce spores only in needles still attached to the twigs. Thus, by early detection (in March and early April) followed by roguing severely damaged trees and pruning the low infected branches of other trees, the disease can effectively be suppressed.



## PINE-PINE GALL RUST
## (WESTERN GALL RUST)

### SYMPTOMS

The fungus Endocronartium harknessii causes globose galls on twigs, branches, and mainstems. The disease is known as western gall rust, Woodgate gall rust, and pine-pine gall rust. As the last name indicates, the rust fungus spreads directly from pine to pine. Many species of 2- and 3-needle pines are susceptible. Damage in Scots pine Christmas tree plantations has increased in recent years. Severe infection can result in poor growth, poor foliage color, and death of twigs, branches, or entire trees.

Individual Scots pines vary greatly in susceptibility. Gall-free and heavily galled trees from the same seed source may be seen growing close together.

### LIFE CYCLE

Infection occurs in late May and early June when powdery yellow masses of spores are liberated from blisterlike fungus structures which break through the bark of mature galls and then rupture. The spores are carried by air currents. Spores that lodge on succulent new shoots germinate during wet weather and start new infections. Symptoms can be seen a year later when swellings develop in 1-year-old twigs. When these young galls are numerous, they give a swollen, beaded appearance to infected twigs and usually cause twig death. The rust has a 3-year life cycle: i.e., galls produce spores 3 years after infection starts.

## DAMAGE

Galls that do not kill the host branches may enlarge for many years, in extreme cases reaching a diameter of 15 centimeters or more on old trees. Beginning usually 3 years after infection, living galls produce spores that initiate new infections. Most spore-producing galls are between 2 and 6 centimeters in diameter.

## PHYTOPHTHORA WILT AND ROOT ROT OF RHODODENDRONS AND OTHER PLANTS

## SYMPTOMS

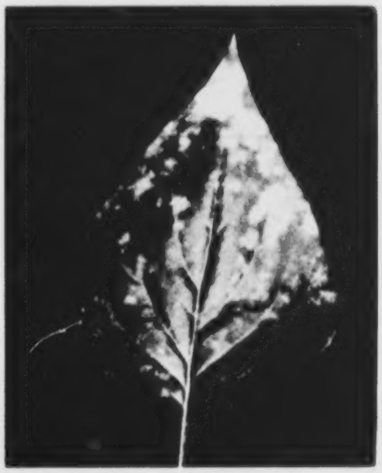
A soilborne fungus, Phytophthora cinnamomi, enters the young roots of many kinds of plants and works its way up to the crown. At first, single branches may yellow and wilt, after which the entire plant may become affected. The wilt disease may be diagnosed by scraping a section of bark from the main stem of the plant near the soil line. Reddish to brown streaks in the wood are an indication of the presence of the wilt fungus. Members of the Heath family, especially rhododendrons, azaleas, and pieris, are damaged in nurseries in southeastern New York. Although the fungus attacks hundreds of kinds of plants around the world, it does not thrive in northern areas.

The disease is most destructive in cool, wet locations in seed, propagation, or nursery beds. Uninjured feeder roots of seedlings, cuttings or transplants are attacked and killed by the fungus. Infection also may take place through wounds and growth cracks which often occur during the second year's growth of seedlings.

The fungus is inhibited by acid soil conditions (pH 4.25 or less), killed by winter freezing of soil, and inhibited by some organic soil amendments and soil substitutes, especially composted bark.

## POWDERY MILDEW

### SYMPTOMS



A white to grayish powdery coating on the surface of the leaves, stems, buds, fruit or other plant parts of roses and many other ornamental plants in mid to late summer is a sign that powdery mildew has become established. The coating consists of superficial, interwoven threads or hyphae of a specialized fungus and its spores. The fungus feeds only on the plant's surface cells and injures the plant very slowly. For this reason, the coating is usually visible before symptoms of injury are. Typical symptoms usually consist of stunting and distortion of leaves, buds, growing tips, and fruit, death of invaded surface tissues, a general decline in plant growth, yellowing of leaves and premature leaf fall.

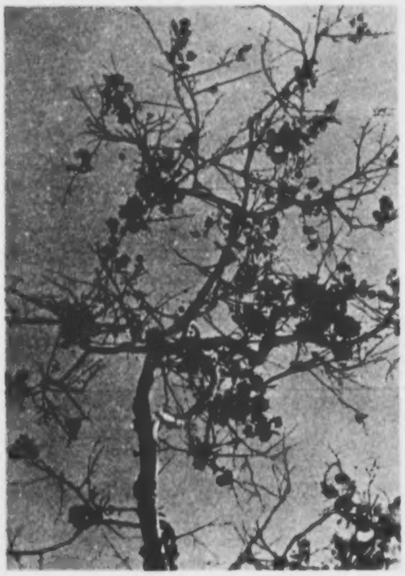
### LIFE CYCLE

One or more species of six closely related genera of specialized fungi cause powdery mildew diseases of ornamentals and roses.

The fungus can survive the winter either in dormant buds, or in resistant microscopic structures called perithecia on infected stems and old leaves. In spring spores are carried by air currents to other plant surfaces where they germinate, produce extensive surface growth and start another disease cycle.

## SYCAMORE ANTHRACNOSE

### SYMPTOMS



Throughout the Northeastern states the common American sycamore may be nearly defoliated by anthracnose from late May through June in about three years out of four. Results of the disease are killing of buds and twigs before new growth starts, blighting of new shoots in cool, wet weather after buds open, and blighting of leaves in early summer. The repeated killing of terminal buds and twigs causes angular deformities of branches and the formation of clusters of successively killed twigs. The causal fungus is Gnomonia platani.

### LIFE CYCLE

The anthracnose fungus spends the winter in cankers on twigs and branches throughout the tree. In the spring spores are produced in the cankers, and are carried by rain to leaves and shoots below. For this reason, only the uppermost and outermost leaves escape the disease during years of severe infection. The fungus can also overwinter in dead leaves on the ground, but this is not an important source of spores in spring.

Moisture is necessary for spread of the fungus. Seashore areas with constant heavy mist or fogs almost always have more disease than drier areas inland. However, rain is not the only strong factor determining severity of anthracnose. Temperatures during early spring govern disease severity. If the mean daily temperatures (the average of maximum and minimum temperature) are between 50 and 55 degrees between budbreak and early leaf emergence, the shoot blight aspect of anthracnose will be severe. If the mean daily temperature during this period is 60 degrees or more, then shoot blight will be slight.

Although affected trees may fail to leaf out at the usual time, or may lose their leaves in June, in about a month they will have a new and healthy crop of leaves. Even severely affected American sycamore trees will not die. Huge native specimens in parks, pastures, and seashore areas where anthracnose is most severe have been defoliated annually for many years, but they have survived and flourished.

SUMMARY OF SELECTED DISEASES OF WOODY ORNAMENTALS

| Name of Disease | Type of Injury | Plant Attacked | Plant Parts Attacked | Infectious or Damaging Stage | Diagnosis | Control Measures |
|---|---|---|---|---|---|---|
| Apple scab | spotted, discolored or dead leaves; defoliation; fruit spotting | Ornamental apple, crabapple | leaves, fruits | fungus | spotted, discolored, or dead leaves; spotted and/or deformed fruits. | Spray throughout growing season.<br>Use resistant varieties. |
| Cedar-Apple Rust | no serious harm on coniferous hosts - Heavy infection can cause retarded growth. Spots on leaves, deformity of shoots and fruit of broadleaf hosts | Cedar, apples, crabapples, hawthorn, quince | stems, leaves, fruit | fungus | swelling or gall-like growths on twigs of redcedar; bright spots on leaves and deformity of fruit and shoots of broadleaf hosts. | Prune off gall-like growths on lightly infected junipers. Spray broadleaf hosts in spring. |
| Cytospora canker of spruce | dead branches and twigs or cankers on stems | Spruces | stems, twigs, trunk | fungus | cankers on stems; dead, deformed or cankered twigs; resin on infected bark. | Prune off cankered or dead branches and disinfect pruning tools between cuts. |
| Diplodia tip blight | stunted and dead needles; twig death leading to branch death | 2- and 3-needle pines | damage to needles, twigs and branches | fungus | needle stunting and/or death; twig and branch death | Prune off diseased parts where practicable; spray 3 times at 10-day intervals beginning as new growth starts. |
| Dutch elm disease | flagging (dying branches), discolored wood, death of tree | Elms | damage to entire tree | fungus | dead or dying branches; discolored wood (in infected branches and twigs) | Control bark beetles in early spring, prune off dead parts at first sign of symptoms, trunk fungicide injection, eliminate root grafts. |
| Hawthorn leafblight | dead or spotted, discolored leaves | hawthorn | leaves | fungus | spotted or discolored leaves | Spray at budbreak and 10 and 20 days after. Do not plant susceptible varieties. |

Diseases of Woody Ornamentals (Cont'd.)

| Name of Disease | Type of Injury | Plant Attacked | Plant Parts Attacked | Infectious or Damaging Stage | Diagnosis | Control Measures |
|---|---|---|---|---|---|---|
| Juniper twig blight | dead twigs, cankers on small stems | Junipers, arborvitae, Atlantic white cedar | needles, stems, twigs, trunks | fungus | dead needles and twigs; cankers on small stems. | Treat with fungicide bi-weekly throughout growing season. Treat before disease appears. Use resistant varieties. |
| Lophodermium needlecast of pine | dead or discolored needles | Pines | needles (can defoliate and kill tree) | fungus | dead or discolored needles | Destroy diseased parts (if practicable). Spray monthly during summer. Plant resistant varieties. |
| Rhabdocline needlecast of Douglas-fir | dead or spotted needles | Douglas-fir | needles (can defoliate and kill tree) | fungus | dead or spotted needles, green at base until premature casting | Rogue out diseased plants or trees (if in a plantation). Plant on slopes, control weeds. |
| Pine-Pine gall rust (Western gall rust) | dead or deformed twigs or cankers on stems | 2- and 3-needled pines | stems, twigs, trunk | fungus | dead or deformed twigs or cankers on stems | Prune off and destroy diseased parts. Chemicals not recommended. |
| *Phytophthora* root rot and wilt of *Rhododendron* | wilting; dying or dead leaves, twigs, or shrubs | rhododendron, azalea, pieris | roots; soil-line stem area | fungus | wilting; root rot; dead or dying plant | Plant less susceptible varieties; do not plant in contaminated soil; remove and destroy infected plants; soil drench for protection. |
| Powdery mildew | powdery white on leaves; perhaps leaf death or defoliation | ornamentals | leaves | fungus | thin, white powdery coating on upper leaf surfaces, sometimes followed by leaf chlorosis. | Spray when symptoms first show. Use resistant varieties |
| Sycamore Anthracnose | discolored or dead leaves, deformed twigs and leaves | Sycamore | leaves, twigs, small branches | fungus | discolored and deformed leaves, dead leaves; deformed, cankered or dead twigs and branches | Dormant treatment or in early spring just before budbreak, at budbreak and when leaves are fully expanded. |

## VI. ORNAMENTALS - WEEDS

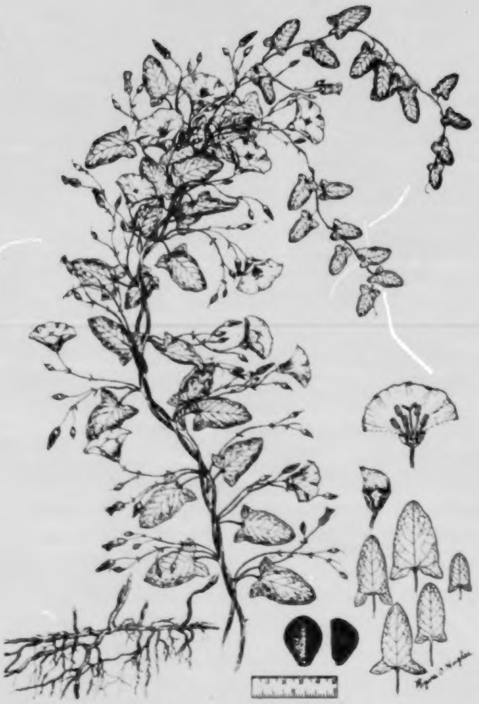
Why get rid of weeds? Weeds compete with crop plants for water, fertilizer, light, carbon dioxide, and other essentials for growth. The greater the growth of weeds, the less the actual growth of the desirable ornamental plants. The weeds also harbor disease organisms and insects which can build up in and attack desirable plants. Weeds in or near a planting of ornamentals are a good source for weed seeds or other propagative parts which can infest clean soil. In a landscape planting, weeds can obscure the ornamental plants and make the area unsightly; it is difficult for the landscaper to show his client what has been done.

Modern weed control is an essential part of any effective cultural program. The producer wants to grow seedlings or liners to salable, high-quality plants quickly in a relatively weed-free environment at a minimum cost. The landscaper wants to give the plants a good start in a weed-free environment to reduce maintenance costs. The grower must understand his crops and his weeds to develop an efficient weed control program suitable for his conditions. Removing established weeds costs money.

The complete, well-planned cultural program starts with good soil that is relatively free of noxious weeds. Choose land in the summer when you can determine what weed species are present. If the land is infested with quackgrass, mugwort, Canada thistle, or nutsedge, it may be best to consider another area. If there are no persistent weeds, planting a good cover crop or frequently disking the land for one growing season may reduce the weed population to controllable levels. Other soil treatments may be necessary before planting. Once the soil is relatively weed-free, do not bring in plants with soil balls containing troublesome weeds. Place clean plants in clean soil.

## BINDWEED

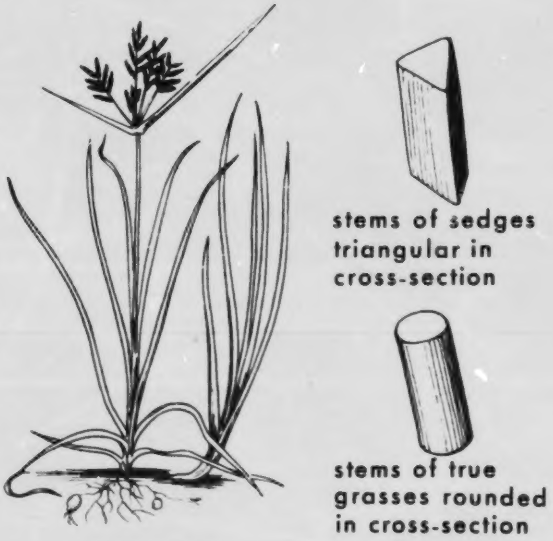
A perennial which propagates by seed and by horizontal roots that bud new plants. The plant grows 2-7 feet long. Stems are smooth, slender, twining, or spreading. Leaf is halberd-shaped (arrow shaped), 3/4 to 2 inches long. Leaf is grooved. The tip of the leaf is round with backward pointing lobes at the base. Flowers are pink, occasionally white, funnel-shaped; about an inch across.



Commonly found in fertile garden and nursery areas. Controlled by frequent cultivation, hand removal of all bits and pieces of root; black plastic and more efficiently by systemic herbicides.

## NUTSEDGE
## (NUTGRASS)

A perennial; multiplies by seed and tubers (nuts) on the roots. Plants 4-24 inches high. Grasslike in appearance but not a true grass. Leaves 1/8 to 1/4 inch wide, 3-6 inches long, thick. Flowers dark chestnut-purple; produced on slender stem (spike). A very serious weed in commercial vegetable


stems of sedges triangular in cross-section
stems of true grasses rounded in cross-section

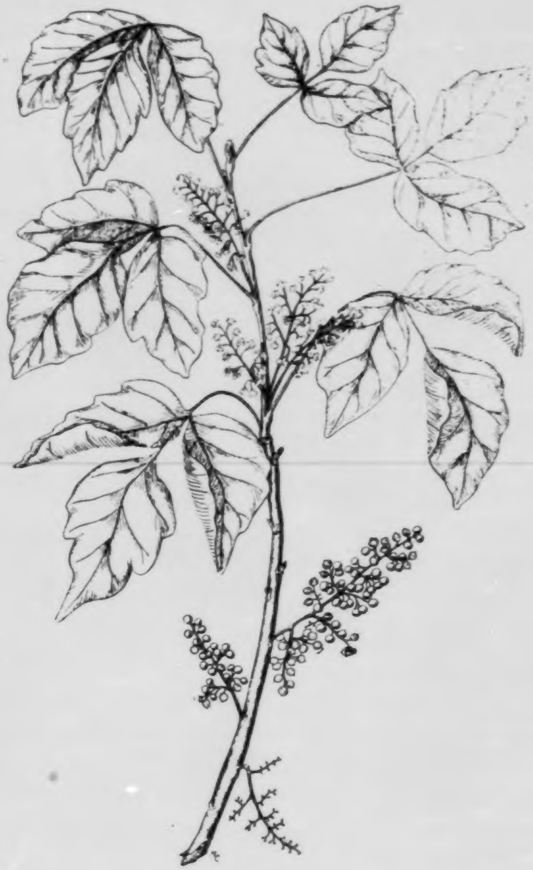
**NUTSEDGE** - *Cyperus esculentus*

fields, nurseries, also found in pastures, waste places, and roadsides.

A very difficult weed to control. The tubers vary in size from a small pea to a very small potato. Tubers are spread on equipment and survive underground many years without growing and then produce a new plant and a new crop of tubers. Black plastic and cultivation aid in control.

## POISON IVY

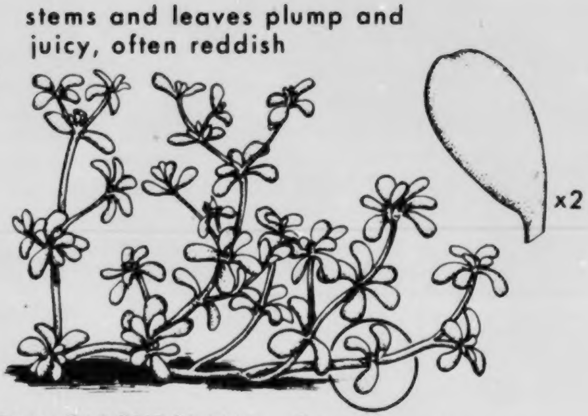
A perennial; multiplies by seeds and creeping rootstocks. Plant upright, trailing, or climbing. Leaves consist of 3 oviate leaflets, 1-1/2 to 4 inches long, smooth, hairy underneath. Leaves red or reddish-yellow in the fall. Flowers small, green, in a head 1-3 inches long. Fruit (berries) a cluster of greenish white waxy berries.



Usually found in woods and damp fields. Do not handle. Poison ivy produces a severe rash. Control chemically.

## PURSLANE
## (PUSLEY, PURSLEY, WILD PORTULACA)

An annual; multiplies by seed. Few gardens are without it. Plants are prostrate (lying flat on ground) 4-12 inches or more in length, branching from all sides of the central root. Leaves are small; wedge-shaped to obovate to oblong, 1/2 to 2 inches long, very thick and fleshy. Both stems and leaves have a reddish tinge. Flowers 1/2 inch in diameter, open only in bright sunshine.

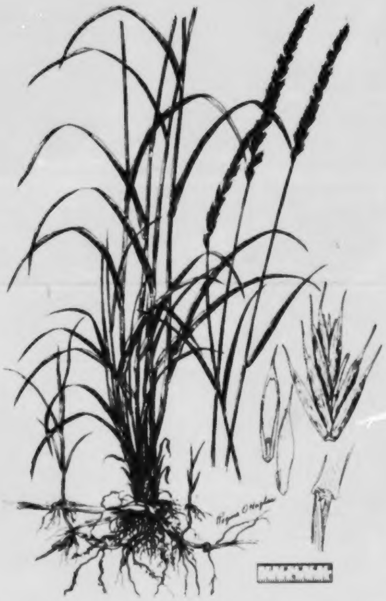

stems and leaves plump and juicy, often reddish
x2

**COMMON PURSLANE** - *Portulaca oleracea*

A troublesome weed in all cultivated soils. Tolerates dry conditions, each plant produces thousands of tiny seeds; if the plant is pulled and left on the ground, it easily takes root again.

Controlled by frequent cultivation before seeds are developed and removing all plants from the garden after they have been cultivated. Black plastic.

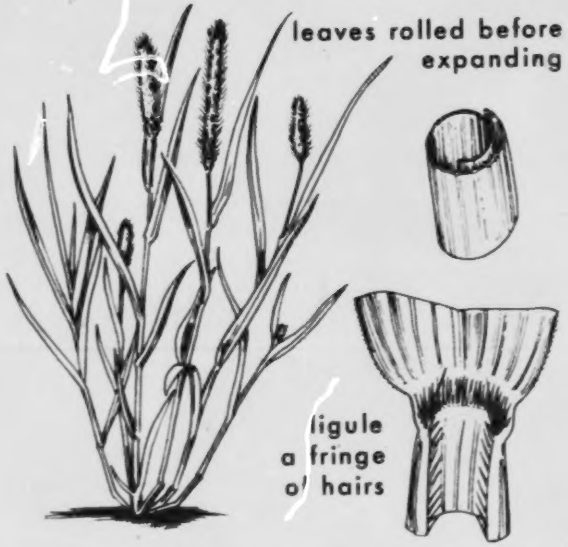
## QUACKGRASS
## (WITCHGRASS, COUCHGRASS)



A perennial; multiplies by seeds and yellowish rhizomes (runners, underground stems, rootstocks). Plant 20-40 inches tall. Leaf (blade) 3-12 inches long; 1/8 to 3/4 of an inch wide, sharply pointed, hairy above, smooth below. Flower spikes 4-8 inches long; resembles a slender head of wheat. The most obnoxious weed in cultivated soils. Once it becomes established in the garden it is very hard to eradicate by cultural means. Frequent cultivations and removal of all rhizomes are necessary since almost any piece of the rhizome is capable of developing into a new plant. Black plastic helps.

## YELLOW FOXTAIL

An annual grass; multiplies by seed. Varies from 1-5 feet in height. Leaf blades 3-6 inches long, flat, smooth, seem to have a spiral twist. Large white hairs on the upper side near the base (sheaf) of the leaf. Spikes (seed heads) 2-4 inches long, yellow-barbed bristles give the head a yellow sheen.



**FOXTAIL** - ***Setaria viridis & Setaria lutescens***

A serious garden weed; also found in pastures, meadows, and roadsides.

## SUMMARY INFORMATION FOR WEEDS IN ORNAMENTALS

| Weed | Classification | Best Timing for Control | Best Stage of Weed for Control | Type of Materials Used for Control | Materials Used |
|---|---|---|---|---|---|
| Bindweed (Field) | Broadleaf perennial | mid-spring or summer | Preemergence for seeding;<br>postemergence for well developed plants | liquid or granular;<br>liquid | Selective preemergence<br>Selective postemergence |
| Yellow nutsedge | narrow leaf perennial | variable | pre or postemergence | liquid or granular | Selective |
| Poison Ivy | Woody perennial | mid-spring or fall | leaves fully expanded | liquid | Selective-foliar contact or translocated herbicide |
| Purslane | Annual | Early spring | Preemergence or germinating seedling | liquid or granular | Selective |
| Quackgrass | Perennial | Early spring | 4-6 inches high | liquid or granular | Selective |
| Yellow foxtail | Annual | Early spring | preemergence | liquid or granular | Selective |

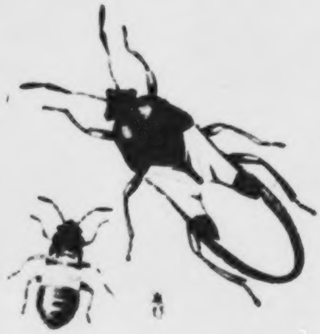
# VII. TURF - INSECTS

Turfgrass is subject to injury by a number of insects. Insects can cause serious damage which may result in considerable repair and replacement expense. This chapter is intended to provide information on the identification of four (4) common insect pests, the injury they can inflict, their habits, and their life cycles.

## CHINCH BUG

### DESCRIPTION

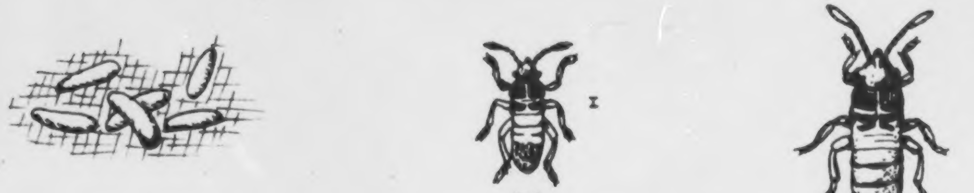
The full-grown Chinch Bugs are about 1/8 of an inch in length. The body is black and the wings, which are folded flat on the back, are white with black markings. There are two forms of the bug; one has long wings that reach to the end of the body, and the other has short wings. The young bugs are wingless and, at first, bright pink in color but become red as they grow older.



### LIFE CYCLE

The Chinch Bugs pass the winter in the turf or in tall grass nearby. In the spring, the females lay eggs on the grass stems. There are two generations of Chinch Bugs a year. The bugs of the first generation hatch during May and June and become full grown in July; those of the second generation hatch in late July and August, mature in late September and October and live in through the winter. Chinch Bug injury is most severe in July and again in September when the bugs of each generation are reaching maturity and feeding most actively.

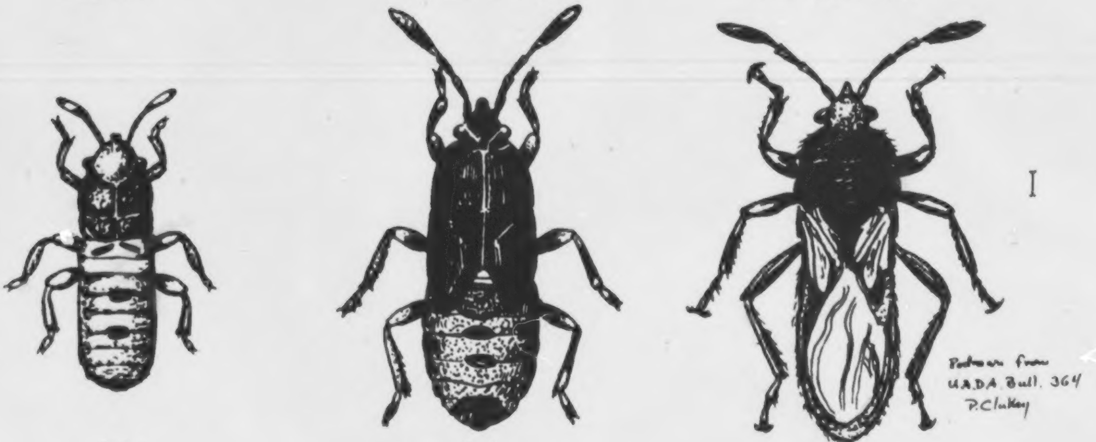
## DEVELOPMENTAL STAGES OF THE CHINCH BUG



Eggs (a)

(b)
1st Instar (red)

2nd Instar (c)



Redrawn from U.S.D.A. Bull. 364
P.Clukey

(d)
3rd Instar

(e)
5th Instar (black nymph)

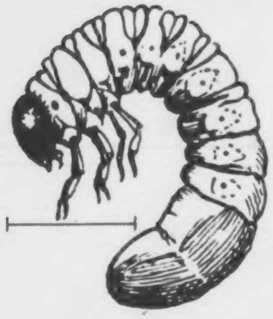
Adult (f)

### DAMAGE

The Chinch Bug injures the grass by puncturing the stems and sucking the plant juices. Injury first shows as a coppery-colored area closely resembling drought injury or sunscald. As the grass dies, the bugs move on to the live grass, so that the injury spreads rapidly and involves large areas. Injury occurs most frequently in sheltered sunny locations and rather seldom in heavily shaded areas. Birds, especially starlings pecking holes in the lawn are a good indication of Chinch Bugs.

## GRUBS

The word grub is a common name applied to the worm or larval stage of several different flies and beetles. The grubs associated with turfgrass belong to the family Scarabaeidae, and the adults are commonly known as scarab beetles. A noted member of this group is the sacred beetle of the Egyptians. The scarab was highly venerated and was placed in tombs with their dead. Its image was commonly carved in stone and precious gems.

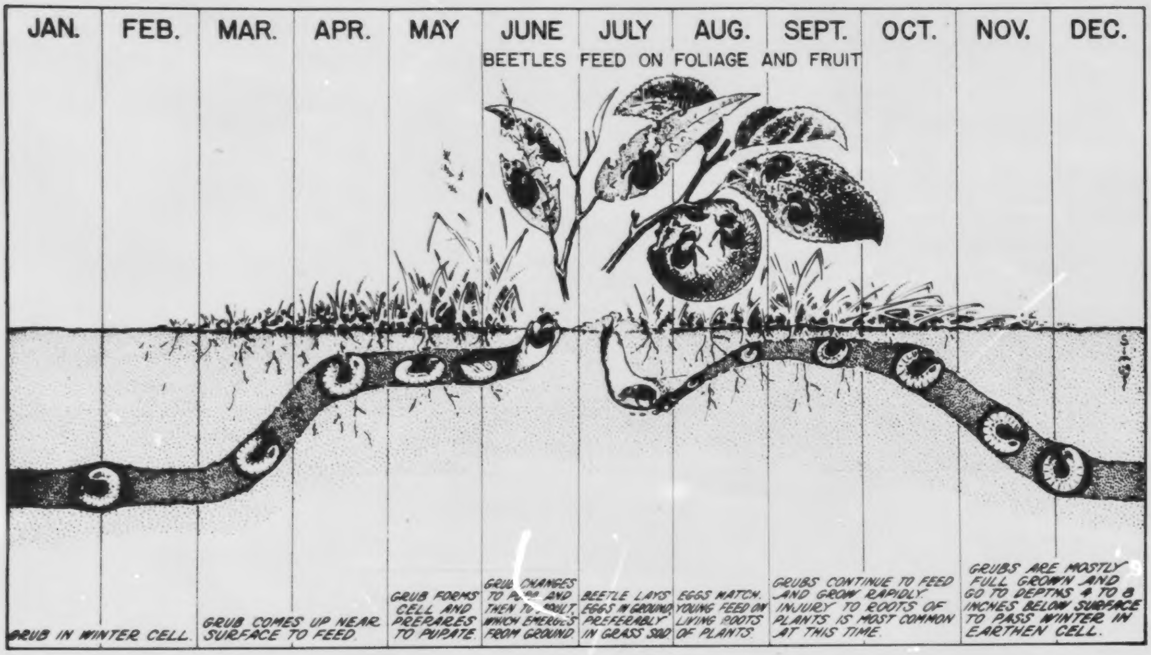


The adult scarabs differ considerably in size and coloration, but the grubs are characterized by their distinctive C-shaped form, yellowish-white body, the brown head, and six prominent legs.

Beetles develop in two distinct ways:

1) Some require one year to complete a life cycle, including the Japanese beetle and European chafer.

2) Others require three years to complete a life cycle, such as the common May beetles and June beetles.

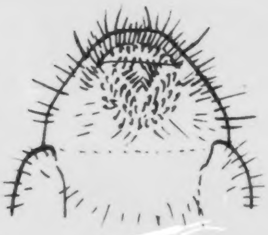

JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
NOV.
DEC.
BEETLES FEED ON FOLIAGE AND FRUIT
GRUB IN WINTER CELL.
GRUB COMES UP NEAR SURFACE TO FEED.
GRUB FORMS CELL AND PREPARES TO PUPATE.
GRUB CHANGES TO PUPA AND THEN TO ADULT, WHICH EMERGES FROM GROUND.
BEETLE LAYS EGGS IN GROUND, PREFERABLY IN GRASS SOD.
EGGS HATCH. YOUNG FEED ON LIVING ROOTS OF PLANTS.
GRUBS CONTINUE TO FEED AND GROW RAPIDLY. INJURY TO ROOTS OF PLANTS IS MOST COMMON AT THIS TIME.
GRUBS ARE MOSTLY FULL GROWN AND GO TO DEPTHS 4 TO 8 INCHES BELOW SURFACE TO PASS WINTER IN EARTHEN CELL.

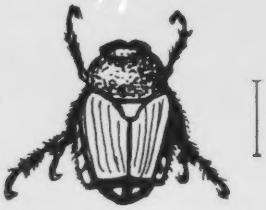
Seasonal life cycle of the Japanese beetle

JAPANESE BEETLE

## DESCRIPTION

The beetles appear in June and are abundant during July and August. They feed on the fruit, blossoms, and foliage of fruit trees, shade trees, and ornamentals. The beetles are about 1/2 inch long with metalic green bodies, coppery-brown wing covers, and 6 small patches of white hairs along the sides and back of the body.





## LIFE CYCLE

The Japanese beetle has a complete generation each year and spends about 10 months of the year in the soil as a grub.

The adult beetles start emerging from the soil during the last week of June and increase in numbers until they reach their peak in late July. Emergence drops off sharply about mid-August, but a few beetles may still be around through September.

The female beetles deposit their eggs in moist soil. The eggs need ample moisture to promote hatching. Dry soil conditions during July and early August are not attractive to the females for egg deposition and hinder hatching of the eggs. Eggs normally hatch in about 10 days.

The tiny grubs start feeding on humus immediately. As they increase in size, they move close to the soil surface and start feeding on grass roots. They grow rapidly and will be about 1 inch long by late September. Most injury occurs during the fall and early spring as the mature grubs feed near the surface.

The Japanese beetle grub can be distinguished from other grubs by the arrangement of hairs on the raster.

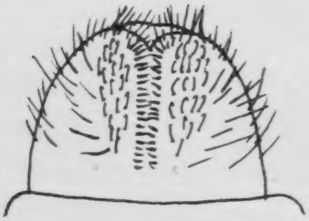
When the soil temperature starts to drop in the fall, they move down 6 to 12 inches in the soil where they overwinter. In April they move back up to the root zone and continue feeding. In late May and June they change to the pupal stage and start emerging as adult beetles in late June.

## SYMPTOMS

Symptoms of grass damaged by grubs are dead, brown patches which can usually be rolled back like a carpet. The roots are severed by the grubs and there is nothing to anchor the turf to the soil. Such areas are also spongy when walked on. Damaged areas may be noticeable anytime from spring until the grass browns off for winter.

## EUROPEAN CHAFER

### DESCRIPTION



The adult stage or beetle forms of the European Chafer are light tan to brown in color and are about 1/2 inch long.

The larval (or grub) stage is the only destructive period of development for this insect. They are about 3/4 to 1 inch long at maturity, found in the ground, shaped like the letter "C" and are creamy white with brown heads. Other insects have very similar grub stages, such as the Japanese beetle and are difficult to distinguish unless experienced in entomology.

### LIFE CYCLE

The European Chafer has a one-year life cycle. The grub stage lives in the soil for a period of ten or eleven months from July until the following June. During the summer and fall months the grubs are very actively feeding on the roots of various grasses, weeds and other plants. The grubs remain in the soil over winter, but are inactive near freezing temperatures. Early in the spring the grubs resume their feeding until mid-May or June. Then pupation occurs and within two (2) or (3) weeks the adults begin to emerge.

### DAMAGE

The grub stage feeds on the roots of turf. The adult beetle stage is not harmful to either man or plants.

### SIGNS THAT THE EUROPEAN CHAFER MAY BE PRESENT INCLUDE

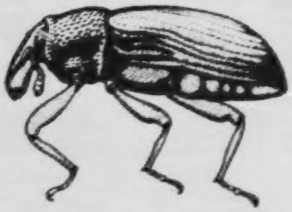
1) Dead or dying spots in lawns.
2) White larvae (grubs) feeding on the roots of plants around the edges of bare spots.

3) Loosened soil in bare spots of lawn, indicating that birds, moles, skunks or other animals have been digging for grubs.

## HYPERODES WEEVIL

### DESCRIPTION

Hyperodes weevil pass through typical egg, larval, pupal and adult stages. Adults are about 3.5 mm (5/32 inch) long and 1.6 mm (1/16 inch) wide. Young adults are soft and orange-brown for several days before they harden and darken to a mottled black. Some adults become shiny black as their clothings of fine hairs and scales are worn off.



### LIFE CYCLE

Hyperodes weevils overwinter as adults in protected areas on or near golf courses, particularly in tufts of fescue and among leaves and debris under bushes and trees. Soon after thawing temperatures in the spring, adults become active and seek feeding and egg-laying sites on fairways and greens.

Larvae hatch after four to nine days. Some larvae begin feeding as soon as they hatch, while others emerge from the original stems and crawl to other feeding sites. The larvae are crescent-shaped, legless, and creamy-white. Their head capsules are dark brown. They vary in length from one mm (1/25 inch) when they hatch to about 4.5 mm (3/16 inch) when fully grown. Although legless, small larvae move about above the soil in the thatch and often bore in several grass plants leaving frass-filled tunnels.

When fully developed, hyperodes weevil larvae burrow about 1/4 inch deep in the soil where they form earthen cells and transform into pupae. The pupae are quite active, rotating in the earthern cells for about five days before transforming into soft, orange-brown adults. After hardening and darkening for several days, these new adults surface and begin feeding.

New adults can be seen during the day moving about on damaged grass. Older adults hide in the thatch during the day and become active at dusk when they crawl to the tips of leaves to feed.

## DAMAGE

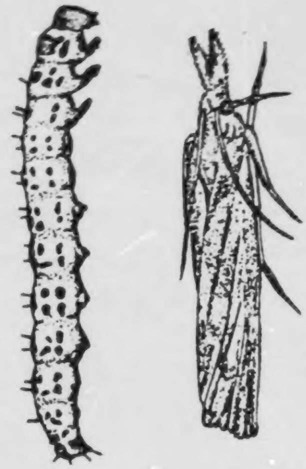
Hyperodes weevil damage is often severe on greens, tees, fairways, etc. Light damage results in a slight yellowing and browning of the turf; moderate damage in small irregular patches of dead grass; and heavy damage in the drying out of large areas of turf. Damage usually becomes obvious late in May or early June.

Grass stems are hollowed out or severed at their bases. Grass stems turn brown and lie flat soon after damage occurs. When damaged grass turns brown, the sod can be peeled back to reveal turfgrass weevil larvae, pupae, and adults about 1/4 inch deep in the soil.

## SOD WEBWORM

## DESCRIPTION

The Sod Webworm moths are one inch long, whitish-gray or brown in color. The projection from the head, which is formed by a pair of small feeler-like structures arising from the lower lip of the mouth, has also given them the name snout moths.



The immature form of the sod webworm moth is a caterpillar about one-fourth to three-fourths of an inch long and light brown in color. The caterpillar is covered with coarse hairs and may have dark spots on the body.

## LIFE CYCLE

The caterpillar overwinters in the silken tunnel, becoming active in the spring. It will attack lawns containing bluegrass, both Merion and Kentucky, Fescue, Bentgrass and other grasses. Sod webworm caterpillars become full grown by June. They pupate in the ground and emerge as adult moths in late June or early July.

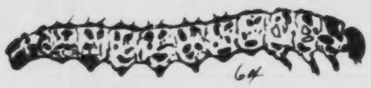
## DAMAGE

The caterpillar stage feeds on grass blades at night, causing irregular brown patches in the lawn. There may be many caterpillars working in a lawn resulting in large areas killed completely. Browned out patches should not be confused with dollar spot or dog injury. Close examination of the damaged area will show a loose silken web containing bits of green droppings leading to a short silk-lined tunnel in the ground. You can find the worms by breaking apart the damaged areas with your hand.

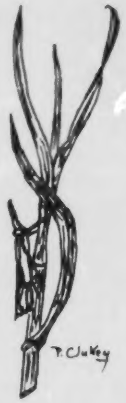
Sod Webworm moths are easily disturbed when one walks across a lawn in the evening. Their peculiar flight pattern, very quick, short, jerky and zig zag may be observed. When at rest, the wings are folded closely about the body.

**Eggs**

**Larval Burrow**



**Larva**


**Resting Adult**

## INFORMATION FOR TURF INSECTS

| Insects | Type | Plant | Part | Life Stage | Control | Injury | Insect | Control |
|---|---|---|---|---|---|---|---|---|
| chinch bug | sucking | grasses | stems | nymphs and adults | larvae and adults | wilting of grass | 5/16" adults black and white; nymphs reddish | insecticides, birds |
| grubs, Japanese beetle, European Chafer | chewing | grass and other plants | roots and underground stems | larvae | larvae | grass, roots | white grubs about 3/4" long | insecticides; milky spore disease and parasites for Japanese beetle grubs only. |
| hyperodes weevil | chewing | Poa annua | stem and crown | larvae | adults and larvae | yellowing of grass as dying of grass | legless, white body, brown head, 3/16" | insecticides |
| sod webworm | chewing | grasses | grass leaves, stems | larvae | larvae | cutting off the grass plants at ground level | 3/4" long, light brown to gray hairy caterpillars | insecticides; birds |

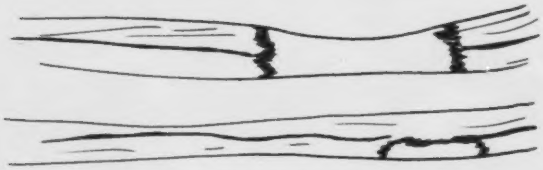
# VIII. TURF - DISEASES

Disease is part of the total interaction between the grass plant and its environment. When we think of disease, most of us consider those problems involving a living organism such as fungus, nematode, bacteria, or virus. The other group of diseases, caused directly by environmental factors -- such as nutrition, moisture, light, pollution (air, soil, and water) and soil structure -- are sometimes termed disorders. In this sense, disease may be a direct result of environmental stress, or it may have an indirect relationship with the environment.

We will here consider only the classic diseases, those induced by fungus organisms. In every instance, plant disease development caused by an organism may be viewed as a triangle with the three sides consisting of (1) a susceptible grass plant, (2) the presence of a disease organism, and (3) an environment favorable for disease development. In most instances after the passage of a very few years, a new turf area will be well populated with most common disease organisms. Thus, the environment remains as the variable that makes the disease interaction successful or unsuccessful.

The environment, as every turfgrass manager knows, may affect the turfgrass plant as well as the fungus. In some situations, severe disease develops when the environment is very unfavorable to grass growth and perhaps only partially favorable to the fungus. Where conditions are favorable for grass growth as well as for growth of the fungus, the disease generally fails to become well established. These examples may be equated to a balance where equal loads (stresses) fail to shift the balance either way, but a relatively greater load on one side will allow the other side to become elevated (either better grass growth or more disease).

## DOLLAR SPOT OF TURFGRASSES



Bluegrasses, bentgrasses, fescues, and zoysia are attacked by the fungus Sclerotinia homoeocarpa which causes dollar spot. The disease name is derived from the dead straw-colored spots about the size of a silver dollar on closecut bentgrass putting greens. Dollar spot may persist from early summer until early fall, and its incidence seems to be higher in seasons with low rainfall, presumably from the adverse effect of low soil moisture on host plants.

### SYMPTOMS

The pattern of symptoms depends largely on mowing practices. Under close mowing conditions the circular straw-colored spots (2" - 3" diameter) are distinctly outlined in the early stages of disease development. With higher cutting heights, the bleached turf spots are irregularly shaped. In the early morning when dew is still on the grass, a white cobwebby growth of the fungus may be seen over the spot. Spots coalesce to cover large areas when the disease becomes severe.

On individual grass blades the invaded tissues are first water-soaked and dark colored. As they dry, the lesions turn light tan to straw-colored with a reddish-brown border. The lesions first occur randomly on the leaf blade, and then frequently extend across the entire blade. Older lesions may become quite long and cause blighting of the entire leaf or cut leaf end.

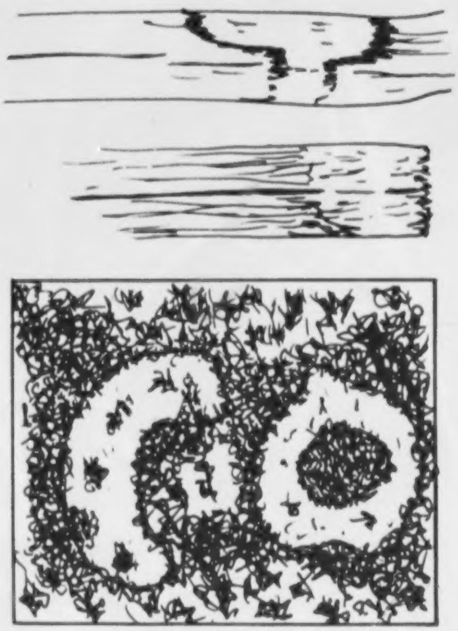
### DISEASE CYCLE

This pathogenic fungus overwinters as black paper-thin flakes, called sclerotia, or on in the soil. In this weather-resistant state the fungus is able to survive under adverse environmental conditions. Survival also occurs in the crowns and roots of infected grass plants in areas where the turf is protected from severe winter conditions. When daytime temperatures reach the 60° to 80°F range, the fungal sclerotia germinate and infection can occur if the leaves are moist.

If environmental conditions become unfavorable for the fungus soon after infection has occurred, or if control measures are exercised quickly, infection may not progress beyond scattered leaf lesions. If the grass is growing rapidly, the problem may disappear after one or two mowings. If favorable weather persists after infection, and if control is not achieved, entire grass plants may be killed and typical "dollar spots" may appear on the turf.

## FUSARIUM BLIGHT OF KENTUCKY BLUEGRASSES

Fusarium blight was first identified in the early 1960's and has become increasingly important in New York. The disease is most severe in the southeastern sector of our state. It is caused by an interaction of environmental factors with the fungi Fusarium roseum and Fusarium tricinctum.



SYMPTOMS

It can be difficult to diagnose this disease in its early stages because the leaf lesions are variable in size, shape, and color. They usually extend across the blade and are yellowish, dull-tan, or reddish-brown.

The disease begins as scattered light green patches 1/2" - 6" in diameter which then may become as large as two feet in diameter, and turn dull tan to reddish-brown. The most diagnostic of these larger diseased patches in the lawn is the "frog eye" pattern in which an apparently healthy green patch of grass is partially or completely surrounded by a ring of dead grass. Distinct streaks, crescents and circular patterns which are found in the affected lawn area are characteristic.

Blighted areas often occur on lawn sites which receive direct sun and are on south-facing slopes, or near sidewalks, driveways, buildings or other "hot spots" in the yard. In the cool weather of autumn, the grass may begin to grow into these dead areas again, but the disease is likely to reoccur in previously affected areas the following summer, and to increase in intensity. Fusarium blight is less of a problem in cool, wet summers.

## DISEASE CYCLE

The *Fusarium* species which cause blight are a normal part of the microbial population in all turfgrasses. They persist in dead grass debris, thatch, and infected crowns, rhizomes and roots. Spores are produced in profusion during the summer, especially during periods of high humidity. Infection is usually the result of placing the plant in a stressed condition. The disease proceeds most rapidly with daytime temperatures of 75° - 90°F and warm evening temperatures, coupled with the stresses which limit the growth of turfgrass plants. Thus, June, July and August are the months when Fusarium blight usually develops. Control measures are designed primarily to avoid the predisposing stresses whenever possible. Such stresses include acid soils, drought, low and frequent mowing, nematode damage, very high temperatures, excessive thatch, some pesticides and excessive nitrogen especially during the summer.

## LEAF SPOT DISEASE

Leaf Spot (Helminthosporium) disease ranks among the most important fungus disorders of turfgrasses, characterized by leaf blighting, leaf girdling and root, rhizome, stolon, and crown rots. It is not uncommon in certain seasons for this disease to become the limiting factor in turfgrass growing in our area.

### SYMPTOMS

The disease occurs on all plant parts. On the leaves it is first seen as minute, water-soaked injury or lesions. These soon enlarge into dark, purplish-red ovular areas 1/4 to 3/8 of an inch long, and 1/16 to 1/8 of an inch wide -- the width being limited largely by the size of the leaf. As the infected areas enlarge, the color of the centers changes to brown and finally, a dull white.

Although any area of the leaf may be attacked, infection is usually more severe on the sheath. Lesions on the leaf sheath are generally not as regular in outline as those on the leaf blade, and in addition the lighter colored center is usually missing. Infection of the sheath is often so severe that the leaf is girdled at this point and drops from the plant. It is this leaf-dropping phase of the disease that has given rise to the name "melting-out".

Occurring in conjunction with infection of the leaves is an invasion of the crowns and ultimately, the roots and rhizomes. The disease in these plant parts is a rot, appearing at first as a reddish-brown decay and finally turning dark brown to black as bacteria and other fungi begin to colonize the tissues. It is not unusual for diseased plants to wilt under soil moisture conditions that would normally seem adequate for growth.

## DISEASE CYCLE

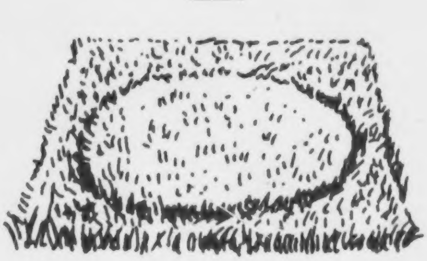
The leaf spot fungi survive the winter months in diseased grass crowns, roots, and rhizomes, and in debris formed from infected leaves. In the spring the spores are produced which are carried up onto leaves by splashing water. These spores germinate and infect the leaves. From these infected areas, new spores are produced which are in turn spread to new leaf parts and neighboring plants. Older leaves appear to be more susceptible than younger ones.

Infection of crowns and roots of new plants also occurs in the spring. With the beginning of warm, relatively dry summer months, the fungus is restricted primarily to the crowns and roots of the diseased plants. However, if cool weather develops during this time, the disease can break out on leaves again.

Melting-out of Kentucky bluegrass is characterized by two phases of development: In the cool, wet months of spring and late fall, the more striking and better known leaf-spot phase is evident; during the summer months the crown and root-rot phase dominates.

## RHIZOCTONIA BROWN PATCH

Rhizoctonia brown patch is one of the major foliar diseases of turfgrasses in our area which is characterized by extended periods of high temperatures and high humidities. A very wide range of grass species may, under the proper environmental conditions, have both the aesthetic and service qualities destroyed within a very short time.



## SYMPTOMS

With the conditions of close mowing, as practiced for putting greens and bowling greens, Rhizoctonia brown patch appears as irregularly shaped patches of blighted turfgrass. Ranging from a few inches up to two feet in diameter, the overall coloration of these patches is usually first a purplish green, which rapidly fades to light brown as the withered leaves dry out.

Where management practices include high mowing, i.e., home lawns, park lawns, and golf course fairways, the disease may involve areas ranging from 2 to 50 feet in diameter. More or less circular in outline, these patches of light brown, blighted turfgrass are usually closely matted to the soil surface, thus creating a sunken or "pocket" effect.

The chief field diagnostic feature of Rhizoctonia brown patch on putting greens is evident during periods of warm, humid weather. At these times dark, purplish "smoke rings", 1/2 to 2 inches wide may border the diseased areas. Usually more prominent in the hours of early morning, these "halos" may fade as the day progresses. On home lawns these "halos" are not evident.

## DISEASE CYCLE

Brown patch survives the winter months in the form of sclerotia either embedded in plant tissue or on the surface of the soil. The disease is also capable of existing for long periods of time in the absence of suitable host plants. Resumption of growth of the fungus occurs when air temperatures reach 64° to 68°F. Under these conditions, thread-like growth extends for only a short distance, and the sclerotium serves as the food source for the fungus. At this stage of development, if the air temperature drops below 62°F, death of the thread-like growth may result. When the average daily air temperatures reaches 73°F, fungus penetration of the leaves occurs. Initial invasion of the leaf tissue is accomplished by entry through stomates and wounds produced by mowing. This invasion continues until the air temperatures reach 80° to 85°F. In this temperature range, particularly in the presence of moisture-saturated atmosphere, brown patch may completely blight a large stand of turfgrass within a period of 6 to 8 hours. When the air temperature reaches 90°F, activity of the fungus stops. Although the disease occurs under conditions of relatively low atmospheric humidity, a moisture-saturated atmosphere greatly aids the development of brown patch. In order for the fungus to spread rapidly to healthy plants, free moisture must be present on the leaves. Soil moisture in the readily available range (field capacity to permanent wilting percentage) apparently does not influence the development of brown patch. The disease does respond sharply, however, to certain fertility and pH levels.

Severity of the disease is much greater in turfgrass grown at high nitrogen plus normal phosphorous and potassium levels, as compared to plants grown with normal balanced fertility. On the other hand, when phosphorous and potassium levels are increased concurrently with nitrogen, there is no measurable increase in disease development. At low nitrogen fertility, with normal levels of phosphorous and potassium, brown patch is much less severe as compared with disease development in plants grown at normal, balanced fertility. When nitrogen, phosphorous and potassium levels are reduced simultaneously, however, disease severity is greater than when the plants are grown at normal balanced nutrition.

Under low nitrogen fertility, pH apparently does not influence disease development. With normal balanced nutrition, brown patch is more severe in the acid range; whereas at high nitrogen fertility, development of the disease is greater in the basic or alkaline range.

Brown patch has been observed to occur most frequently and with greater severity on short-cut turfgrasses. This is thought to be due primarily to the more abundant and uniform supply of wound-type infection as a result of frequent mowings.

## SUMMARY OF COMMON DISEASES OF TURF

| Name | Causal Agent | Plant Affected | Symptoms | Disease Cycle | Relation to Climate | Control |
|---|---|---|---|---|---|---|
| Dollar Spot | Sclerotinia | grasses | Bluegrass; bleached leaf spot with dark tan border, in patches.<br>Bentgrass; bleached patches the size of silver dollar. White cobwebby mycelium present during early morning dew. | Overwinter as dormant sclerotia or mycelium in plant crowns or roots, or in thatch. Becomes active in spring and summer. | Disease is greater with high humidity and relatively dry soil. | Many fungicides, adequate nitrogen nutrition, avoid nighttime watering. Use recommended varieties. |
| Fusarium Blight | Fusarium | grasses and many others | Irregularly shaped bleached to mottled leaf spots with indistinct borders; patches can be irregular crescents or circles of dead grass surrounding a patch of healthy grass. | Overwinter as dormant spores or mycelium in plant crowns or roots, or in thatch. Plants generally are infected, but disease appears mostly after plant becomes stressed. | Disease is greater when soil pH is below 6.2, surface soil becomes dry, plant is in full sun, after large amounts of nitrogen are applied, or in heavily thatched turf. | First avoid stress factors (see "climate"), and, if needed, follow with fungicide drenches in early summer. Use recommended varieties. |
| Leaf Spot | Helminthosporium | grasses | Oblong brown leaf spots with dark brown to purplish-black borders. General chlorosis of leaf. Generally not seen in distinct patches. | Overwinters as dormant mycelium in plant tissue and thatch. Becomes active in spring and again in fall. Crown rot may occur in summer. | Leaf spot is greater in cool, wet months, and crown rot occurs in warm, dry months. | Avoid excessive nitrogen; use resistant varieties and fungicides |
| Brown Patch | Rhizoctonia | grasses and many others | Bluegrass; patches of light brown blighted grass.<br>Bentgrass; irregular patches of purplish green to brown grass. Dark "halo" occurs around patch in early morning after warm, humid night. | Overwinters as dormant sclerotia in plant tissue, soil, or thatch. Becomes active in summer. | Disease is prominent in hot, humid weather, especially where an abundance of nitrogen is supplied. Also known to occur in fall, winter, and spring. | Avoid excessive nitrogen; use fungicides. |

## IX. TURF - WEEDS

Hundreds of weeds may invade turfgrass areas under specific environmental and use conditions. The following weed descriptions were chosen to represent a few of the more common weeds found in turfgrass areas. In reviewing the weed descriptions and illustrations, keep in mind that the appearance of many of these weeds will vary greatly with the stage of growth of the plant, the climatic conditions, the usage of the area, and the turf maintenance practices followed (cutting height, fertility level, etc.)

### REFERENCE TERMS USED IN WEED DESCRIPTIONS

| | |
|---|---|
| Axil | Point where a leaf or secondary branch joins the stem; the upper angle of the junction of the stem and leaf. |
| Axillary | Situated in, growing from, or pertaining to an axil. |
| Bract | Small leaflike structure surrounding a flower, belonging to an inflorescence, or sometimes a stem. |
| Compound | Two or more similar parts united in a whole. |
| Decumbent | Curving upward from a horizontal or inclined base. |
| Disk flower | Tubular flowers in the middle of the composite head which may be surrounded by ray flowers. |
| Glumes | A pair of empty bracts at the base of a grass spikelet. |
| Lobes | A division, segment or projection of the basic leaf form. |
| Inflorescence | Flowering part of a plant. |
| Margin | Edge or border of a leaf. |
| Node | A joint of a stem that is sometimes enlarged. |
| Oblong | Longer than broad with the sides nearly parallel. |
| Opposite | Leaves, stems, etc., on the same node at opposite sides of the stem or petiole. |
| Ovate | Egg-shaped with the broadest end near the base. |
| Palmate | Lobed or divided to appear like a hand. |

| | |
|---|---|
| Panicles | Loose, irregularly compound inflorescence with the flowers borne on individual stalks. |
| Pedicel | Stalk of a single flower in a compound inflorescence. |
| Petiole | Stem or stalk of a leaf. |
| Procumbent | Trailing or prostrate stem. |
| Pubescent | Covered with short soft hairs. |
| Ray flower | Marginal petal-like flowers of some composites. |
| Rhizomes | Underground stem which provides means for the spread of some perennial plants. The term rootstalk is used in place of rhizome in many instances. |
| Rosette | Cluster of leaves formed without discernible upright stem. |
| Rough | Rough to the touch because of hairs, minute points, or teeth. |
| Sessile | Without a petiole, no attachment stalk. |
| Sheath | Lower part of the leaf that encloses the stem of grasses. |
| Smooth | Smooth to the touch and without hairs. |
| Spike | Simple inflorescence with flower sessile or nearly so upon an elongated stem. |
| Spikelet | A unit of inflorescence of grasses and sedges consisting of one or two flowers between two glumes. |
| Stolon | Above-ground creeping stem which roots and develops new plants at the nodes. |

## LAWN WEEDS

### What is a Weed?

A weed is any plant growing out of place -- where it is not desired. Bluegrass growing in a bentgrass green would be considered a weed. Bentgrass in a bluegrass lawn is a most objectionable weed. Yet each grass is excellent for its own particular purpose. With few exceptions, dicots, such as chickweed, clover, plantain are weeds. Most weeds possess a vigorous capacity for growth and survival under adverse conditions. Some weeds are universal, while others adapt themselves only to certain areas of the country. Research has given us the means to selectively control a large majority of these lawn pests, but in each section of the county there still remain those few that defy treatment.

## Sources of Lawn Weeds

Most lawn weeds result from seeds deposited in the soil long ago. Some seeds may remain inactive for 50 years or more, and then spring to life under proper conditions of warmth, light and moisture. These weeds generally germinate and mature when the soil is cultivated, or when bare spots develop. The possibility of introducing weeds into the soil from top quality, properly cleaned lawn seed or fertilizers is practically non-existent.

Topsoils, manures and composts usually contain an abundance of weed seeds. A new crop of weeds can be expected whenever these additives are used.

Weed seeds may be transported from place to place by many methods. Dandelion seeds can be carried many miles by the wind, while the sticky seeds of Buckhorn and Plantain are transported by clothing and animals.

When disturbed, ripe seedpods of Oxalis explode and throw their seeds many feet. Thus, bare spots, or thin turf offer a continuous source of weed infestation.

## The Two Types of Lawn Weeds

Turf weeds are divided into two categories:

Monocots (Mono meaning one) emerge from the seed with a single seedling leaf. All grasses fall into this classification. The most distinguishing characteristic of a monocot are veins that run parallel to each other. Examples: Crabgrass, Goosegrass, Wheat, Corn.

Dicots (Di meaning two) emerge from the seed with two seedling leaves. The most distinguishing characteristic of a dicot are veins that form a net-like pattern. Examples: Dandelion, Shepherd's Purse, Clover, Plantain.

Monocots and Dicots may be Annuals, Biennials or Perennials.

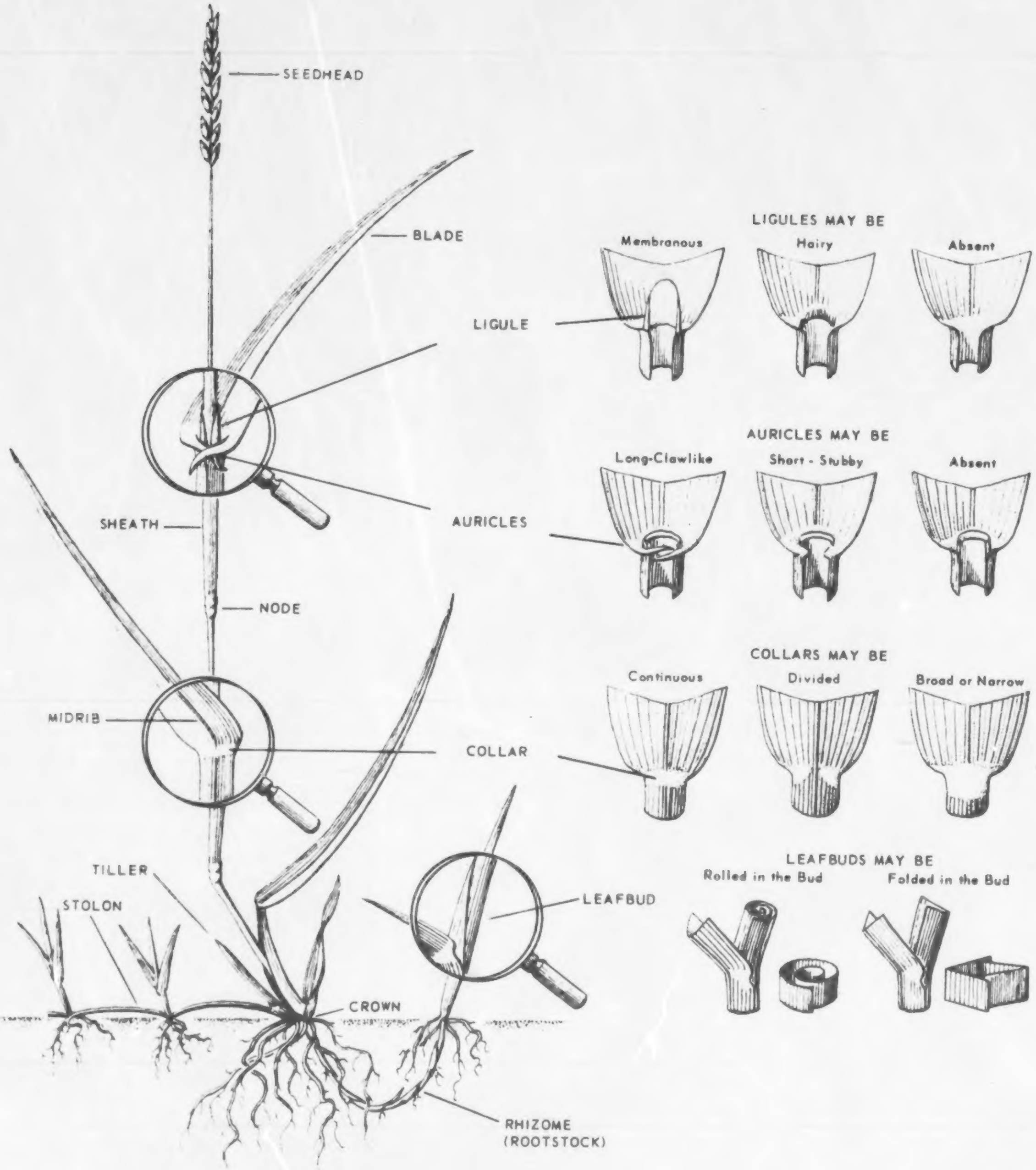
Annuals - Of a single year duration.

Biennials - Of two years duration, generally forming only leaves the first year and producing flowers and seeds the second year.

Perennials - Of more than two years duration; recurring year after year.

Learning to identify weeds and turfgrasses is not particularly difficult, but like most other subjects, requires a certain amount of study and observation. Each growing plant has its own characteristics, peculiarities and growth habits. Very few people can identify all of the vegetation within a given turf area. But a certain basic knowledge can be invaluable in prescribing products and controls. The following dicots and monocots are common throughout most of the country.

# Parts of a grass plant

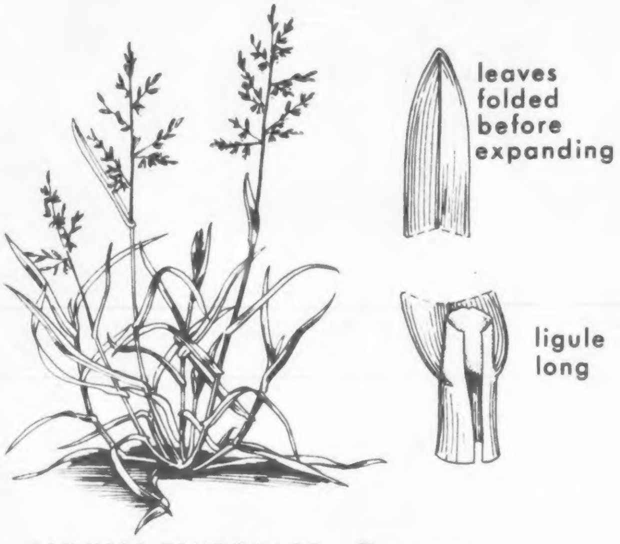


## MAJOR IDENTIFYING PARTS OF MONOCOTS

| | |
|---|---|
| Blade | The upper portion of the leaf, divided from the rest of the plant by the collar and ligule. Blades of different species vary in size, shape, type of tip, smoothness and hairiness. Are either rolled or folded in the bud. |
| Sheath | The lower portion of the leaf which wraps around the stem. May be rough, smooth, hairy, cylindrical or compressed. |
| Ligule | The appendage which clasps the stem at the junction of blade and sheath. The type (membranous and hairy) and shape (tall, short, toothed, etc.) are fairly uniform within a given species. |
| Auricles | Appendages projecting from either side of the collar and may or may not grasp the stem. |
| Collar | The area on the outer side of a leaf at the junction of the blade and the sheath. It is generally lighter in color than the rest of the leaf, and may be broad or narrow, continuous or divided by a mid-rib. |

### ANNUAL BLUEGRASS

Annual bluegrass (Poa annua) is an annual grass having fine, light green leaves. Seed which is the primary means of reproduction is usually very prolific which tends to give a whitish appearance to areas infested with this weed. Growth occurs predominantly during cool periods of the year such as late winter, early spring and fall. Dying-out occurs rapidly during hot weather which results in brown areas in lawns infested with this weed during summer months.

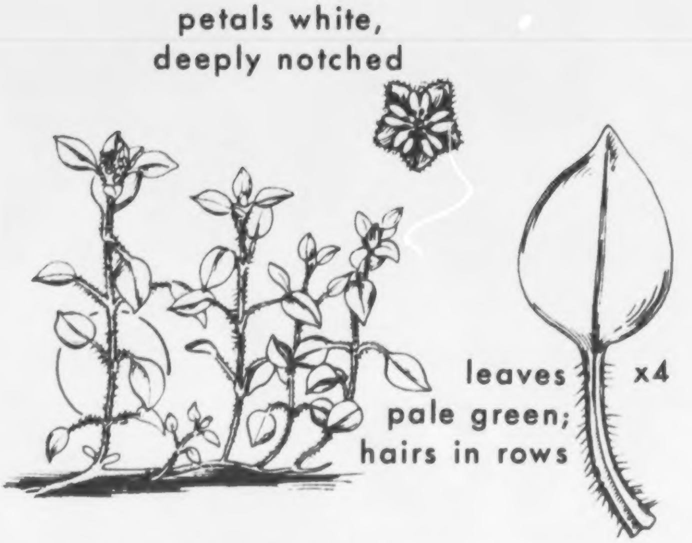


**ANNUAL BLUEGRASS** - *Poa annua*

## CHICKWEED

An annual or winter annual; multiplies by seeds and rooting at the nodes. Stems very branched, creeping, or weakly ascending. Leaves 1/4 to 1/2 inch long, ovate, and smooth. The flowers are very small and white.

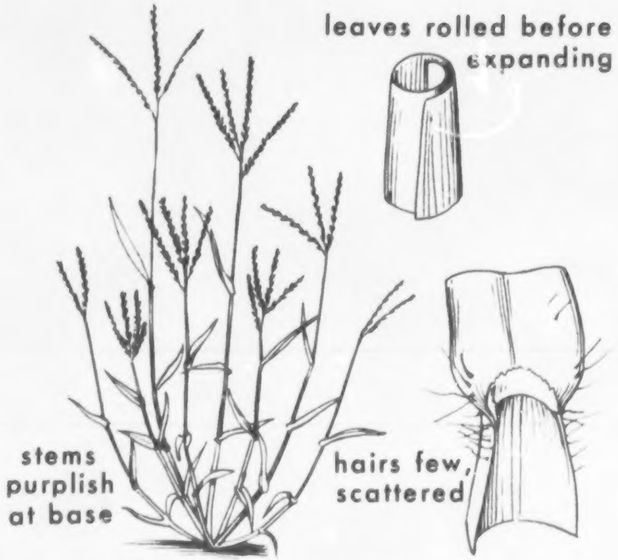
Frequently found blooming in winter. A serious weed in cultivated fields, gardens, and lawns.


petals white, deeply notched
leaves pale green; hairs in rows
x4

**COMMON CHICKWEED** - *Stellaria media*

## CRABGRASS

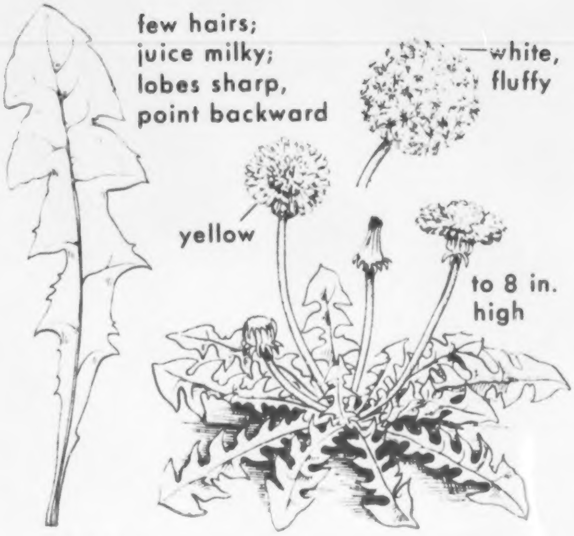
An annual; multiplies by seeds and by stems rooting at the lower nodes. Stems (culms) branching and spreading, often a purplish cast to the plant. Leaf (blade) 2-6 inches long, 1/8 to 1/4 inch wide, sharply pointed, hairy, or smooth. Seed stock (spikes) 2-5 inches long, generally purplish or reddish brown, arranged in a whorl at the end of the spike like fingers of a hand.



**SMOOTH CRABGRASS** - *Digitaria ischaemum*

Rarely is this weed absent from cultivated soils or lawns.

## DANDELION



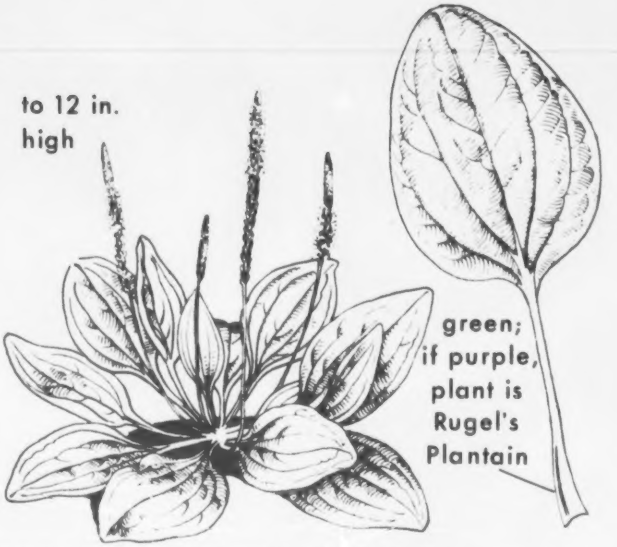
**DANDELION** - ***Taraxacum officinale***

A perennial which propagates by seed and by shoots from roots. Wherever man has cultivated the soil, dandelion has established itself. The root is large, thick, fleshy growing to a length of 20 or more inches. Any piece of root is capable of forming a new plant. Leaves are basal (form a rosette of leaves growing close to the soil level). Vary from 3-13 inches long, lance-shaped, deeply and irregularly lobed and toothed. The divisions usually point toward the base. Flowers are large, deep golden yellow. Young dandelion plants are an excellent source of early spring salad greens and potherbs.

Found wherever there is soil. An extreme nuisance in lawns. Chemical control is the only practical control measure.

## BROADLEAVED PLANTAIN

A perennial which propagates by seed. Plants commonly form a rosette of leaves at soil level. Leaves are long, ovate, smooth; rounded at tip and base. Five to 7 prominent veins extending from the leaf tip to the base form a channeled petiole (leaf stem). Dull colored flowers are borne on slender spikes 3-12 inches or more in length.

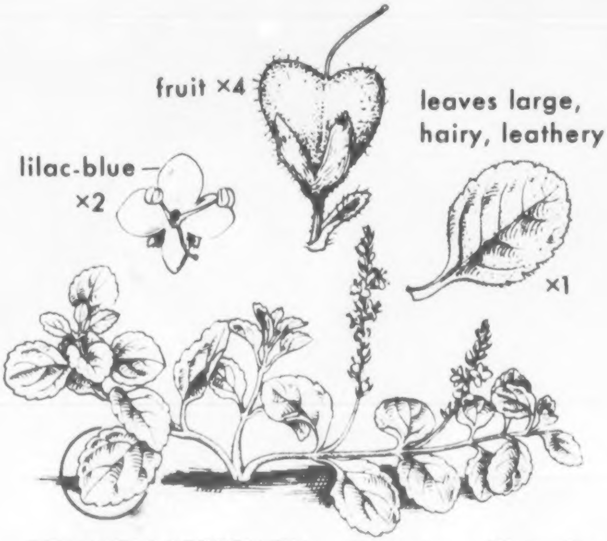


**BROAD-LEAVED PLANTAIN** - *Plantago major*

Commonly found in lawns and occasionally in gardens.

## VERONICA

Veronica (speedwell) can be an annual or a perennial. It is propagated by both seed and rooting stems. Growth is prostrate in nature. Leaves are generally small and circular with scalloped edges. Bears small, blue flowers in abundance in early spring. Flowers are insignificant on some species.



**COMMON SPEEDWELL** - *Veronica officinalis*

## SUMMARY INFORMATION FOR TURF WEEDS

| Weed | Weed Classification | Best Timing For Control | Best Stage of Weed for Control | Type of Materials Used for Control | Materials Used |
|---|---|---|---|---|---|
| Annual Bluegrass | Grassy | | | | No good control to date |
| Chickweed | Broadleaf | Early fall or when it appears before seeding | Postemergence | Liquid. | Selective herbicide - read the label. Some materials cannot be used in hot weather or over shrub and tree roots. |
| Crabgrass | Grassy | Late April. Usually when forsythia finishes flowering. | Preemergence | Granular or liquid. | Selective herbicides. Depends on whether you are seeding and the grass species being treated. |
| Dandelion | Broadleaf | Early fall or mid-spring | Postemergence seedling | Liquid or granular. | Selective herbicides. |
| Plantain | Broadleaf | Early fall or mid-spring | Postemergence seedling | Liquid or granular. | Selective herbicides. |
| Veronica Creeping Speedwell | Broadleaf | Early fall<br>Early spring | Postemergence | Liquid | Selective herbicies - may injure mature turf. |

# ACKNOWLEDGEMENTS

The contents of this training manual for ornamentals and turf were supplied by specialists from several agricultural fields. It has been edited by Edward Zuchorski, Jr., Horticulturist, Cooperative Extension, Chemung County.

Those making contributions are as follows:

| | |
|---|---|
| Arthur Bing | Weeds in Ornamentals |
| J. E. Dewey | Chemicals-Pesticides Program |
| G. L. Good | Ornamentals - Plant Culture |
| W. T. Johnson | Tree-Shrub Insects |
| J. E. Kaufmann | Turf Weed Control |
| Robert O'Knefski | Turf |
| R. F. Pendleton | Chemicals-Pesticides Program |
| W. A. Sinclair | Tree and Shrub - Diseases |
| R. W. Smiley | Turf Diseases |
| H. Tashiro | Turf Insects |

The writers were assisted by New York Cooperative Extension Agents J. Jansen, Orange County; W. McEvoy, Capital District Specialist; I. Gillow, Erie County.

Illustrations on pages 76, 78, 79, 96, 98, 116, and 147 by Carlton Ryan, Media Services, Cornell.

Much of the material in Chapters 1, 2, and 3 have been taken from the draft of the Agricultural-Plant Category Manual developed for EPA by B. Jack Butler and Marshall McGlamery of the University of Illinois; C. C. Russell, Oklahoma State University; Harold Lembright, Dow Chemical Company; Arthur H. Retan, Washington State University; David Quinn, West Virginia University; and J. E. Dewey as part of a Cornell-EPA Pilot Study Contract. Additional material from the Pennsylvania State University has been used.

# PRACTICE STUDY QUESTIONS

# ORNAMENTALS AND TURF CATEGORY

# FOR

# CERTIFICATION OF COMMERCIAL PESTICIDE APPLICATORS (NY-NJ)

(Information on which these questions are based can be found in the Core Manual, Category 3 Manual, Cornell Recommends for Trees and Shrubs, and Cornell Recommends for Turf. The correct answers to these study questions are on page 7.)

1. Poison ivy is classified as an:

   a) annual

   b) woody perennial

   c) herbacious perennial

   d) bi-annual

2. If you were called in to treat Fusarium blight on turfgrass, which of the following fungicides is recommended?

   a) Dyrene

   b) Kromad

   c) benomyl

   d) PCNB

3. Reentry into treated fields refers to:

   a) the time it takes for insects to reinfest treated areas.

   b) the period of time after restricted pesticide application that workers are required to wear protective clothing when working in the field.

   c) the moving of pesticide equipment into an area that has just been inspected for insect or disease problems.

   d) all of the above.

4. Growing conditions can influence plant sensitivity to chemical injury.

   a) true

   b) false

5. What appears to be drought injury of a turf area may be an indicator of chinch bug injury.

   a) true

   b) false

6. The best stage to control crabgrass is as a preemergence treatment.

   a) true

   b) false

7. Substances added to the spray mixture to aid or improve the performance of the main ingredient are called:

   a) wetters

   b) adjuvants

   c) emulsifiers

   d) spreaders

   e) all of the above

8. Proper identification of the pest or pest damage is the first step in controlling a pest problem.

   a) true

   b) false

9. Insects can injure plants in what way?

   a) boring

   b) chewing

   c) sucking

   d) all of the above

10. What part of a tree is attacked by apple scab?

    a) buds

    b) stems

    c) leaves

    d) bark

11. Diplodia twig blight injury appears as:

    a) needles dropping off tree

    b) dead needles, twigs and branches

    c) terminal part of tree starts to yellow

    d) twisted stems

12. Personal contamination or poisoning can be avoided by:

    a) using a creeper or piece of linoleum on contaminated ground when making repairs to machinery

    b) using a scrubbing brush and rubber gloves when cleaning

    c) wearing a respirator when welding spray machinery

    d) all of the above

13. Volatile soil pesticides that are used to eliminate weeds, diseases, or insects are called fumigants.

    a) true

    b) false

14. Ways in which weeds can injure plants or crops is:

    a) reduce crop quality

    b) reduce yields

    c) increase production costs

    d) all of the above

15. What is the formula used for measuring the total area (sq. ft.) of a rectangular area?

    a) L X H = Area (Sq. ft.)

    b) H X W = Area (Sq. ft.)

    c) W X L = Area (Sq. ft.)

    d) 1/2 X B X H = Area (Sq. ft.)

16. A diaphragm pump would be a good choice when using abrasive wettable powders.

    a) true

    b) false

17. When your sprayer is operating properly a pressure regulator assures that a constant quantity of spray material is delivered to the nozzle.

    a) true

    b) false

18. Turf herbicides are best applied with what type of nozzle?

    a) fan or flat pattern

    b) flooding fan

    c) full cone

    d) broadcast

19. Multipurpose sprayers can be used for:

    a) weed spraying

    b) landscape spraying

    c) nursery blocks

    d) all of the above

20. If the hose in the suction line is too small the spray pump will starve.

    a) true

    b) false

21. With mist blowers one normally applies pesticides:

    a) to the point of runoff

    b) by timed application

    c) at ultra low volume

    d) all of the above

22. A rectangular lawn 200' wide x 650' long contains how many acres?

    a) 2

    b) 3

    c) 4

    d) 5

23. A common pest of ash in New York State is:

    a) Japanese weevil

    b) scab

    c) oystershell scale

    d) bagworm

24. The Eastern Spruce Gall Aphid can best be treated with an oil spray in Southeastern New York during:

    a) April

    b) March

    c) June

    d) May

25. In order to control Sycamore (Platanus) Anthracnose the tree must be sprayed:

    a) before trees break bud

    b) at bud break

    c) when leaves are expanded

    d) all of the above

26. Cankerworms can be controlled with carbaryl at what time of the year?

    a) April

    b) May

    c) June

    d) July

27. What pesticides are used for the control of chinch bug?

    a) carbaryl

    b) Aspon

    c) Diazinon

    d) Dursban

    e) all of the above

28. Oystershell scale on ash can be treated effectively while dormant with:

    a) malathion

    b) carbaryl

    c) lindane

    d) 60 or 70 second oil

29. How much 80 WP carbaryl formulation per 100 gallons of water is used to control cankerworms?

    a) 2 lbs.

    b) 1 qt.

    c) 1.25 lbs.

    d) 3 lbs.

30. A certified commercial applicator applying pesticides to turf must know how to calculate the total area to be treated so that he can estimate costs and know the right amount of pesticide to use. He must also be able to use the recommendations to determine the best pesticide to use. The following problem can be answered from your Category 3 Manual, the Turfgrass Recommendations for 1976, and knowing the number of square feet in an acre (refer to your Core Manual if you don't know).

    It is a practical problem of the kind that any certified turf applicator should be able to solve. Work the answers out, using your manual and recommends then compare them with the answers given.

    You have contracted to control broadleaf weeds, mostly dandelions and plantains in turf on a country estate. The property is rectangular in shape and is 545 feet long by 400 feet deep. The house is rectangular, 60 x 100 feet. The driveway is 12' x 100'. There is a circular wading pond that is 80 feet in diameter. There is a triangular shaped woods at one end of the property that is 260' wide by 400' deep. The rest of the property is in turf, all of which is to be sprayed. You will use a low pressure boom sprayer calibrated to deliver 20 gallons per acre at its operating speed of 4 mph and 30 pounds pressure.

    Answer the following questions:

    a) What is the total area of the estate (in square feet)? ____________ sq. ft.

    b) How many acres (approximate) in this? __________ acres.

    c) What is the area of the house? __________ sq. ft.

d) What is the area of the driveway? _____________ sq. ft.

e) What is the area of the pond? _______________ sq. ft.

f) What is the area of the woods? _______________ sq. ft.

g) What is the total area not in turf? _____________ sq. ft.

h) What is the area of turf to be sprayed? _____________sq. ft.

i) How many acres is this (to nearest half acre)? ________ acres.

j) What herbicide would you use? ________________.

k) At what rate active ingredient would you apply it? ________ lbs.

l) If there are 4 lbs. active ingredient in one gallon of formulation, how much formulation would you use per acre? ___________ qts.

m) How much formulation would you use for the job? ___________ qts.

n) How many gallons of spray would you use? ____________ gallons.

## ANSWERS TO STUDY QUESTIONS

1 b; 2 c; 3 b; 4 a; 5 a; 6 a; 7 e; 8 a; 9 d; 10 c; 11 b; 12 d; 13 a; 14 d; 15 c; 16 a; 17 a; 18 a; 19 d; 20 a; 21 b; 22 b; 23 c; 24 a; 25 d; 26 b; 27 e; 28 d; 29 c; 30 a - 218,000; b - 5; c - 6000; d - 1200; e - 5024; f - 52,000; g - 64,224; h - 153,776; i - 3.5; j - 2,4-D; k - 1 lb; l - 1 qt; m - 3.5 qts; n - 70 gals.

7/76

# POISONING HAZARD TO HONEY BEES OF INSECTICIDES AND MITICIDES ON BLOOMING CROPS

| Use Rating | Residual Toxicity | Material |
|---|---|---|
| Hazardous to honey bees at any time | High, 1 day to 2 weeks | arsenicals, Azodrin, Baygon, Bidrin, carbaryl (Sevin), carbofuran (Furadan), chlorpyrifos (Dursban), Dasanit, dichlorvos (Vapona), dimethoate (Cygon), dinoseb, endothall, EPN, fenthion (Baytex), Guthion, heptachlor, Imidan, lindane and benzene hexachloride, malathion D, malathion ULV, Matacil, Methyl Parathion, Methyl Trithion, naled (Dibrom) D, parathion, Phosdrin, phosphamidon. |
| Not hazardous if applied in either evening or early morning when honey bees are not foraging, except during periods of high temperature in these times | Moderate, 3 hours to 1 day | Abate, carbophenothion (Trithion), Carzol, chlordane, demeton (Systox), dioxathion (Delnav), Di-Syston EC, endosulfan (Thiodan), endrin, ethion, heptachlor G, malathion EC, methomyl (Lannate SP), methoxychlor, Meta-Systox-R, Morocide, naled (Dibrom) EC, VC-13 Nemacide, Orthene, Perthane, phorate (Thimet) EC, G, Phostex, Phosvel, TEPP, Thanite, Torak, toxaphene, trichlorfon (Dylox), Zolone. |
| Not hazardous to bees at any time | Low, 1 hour to 1 day | Acaraben (chlorobenzilate), Acaralate (chloropropylate), allethrin, Baygon G, carbaryl (Sevin) G, carbofuran Furadan) G, Dasanit G, Dikar, Di-Syston G, Galecron and Fundal SP, Karathane, Kelthane, lime-sulfur, malathion G, Morestan, oil sprays (Superior), propargite (Omite), Pentac, Plictran, pyrethrum, rotenone, sulfur, Temik G, tetradifon (Tedion). Most herbicides and fungicides. |

Abbreviations: EC - emulsifiable concentrate; D - dust; ULV - ultra low volume; WP - wettable powder; G - granular; SP - soluble powder